A REFERENCE TO MEDIC CURRICULUM

VOLUME 1 BASIC SCIENCE

REVIEWED AND UPDATED IN JANUARY 2022

CONTENTS

HEALTH CARE CONCEPT

OBJECTIVES

At the end of this module, the learner should be able to:

- define health

DEFINE PUBLIC HEALTH

- describe new philosophy of health and dimension of health
- mention the concept of wellbeing
- describe determinants of health
- describe the spectrum of health
- describe changing concept of health
- identify and prioritize the health problems

Teaching Methods

- Lecture & Discussion

DEFINITION OF HEALTH

There are many definitions of heath. The widely accepted definition of health is that given by World Health organization (WHO) in 1948.

WHO Definition of Health

"Health is a state of complete physical, mental and social wellbeing and not merely an absence of **disease or infirmity**".

There are many criticisms that the WHO definition of health is too broad. It is considered by many people as an idealistic goal than a realistic proposition. The WHO definition of health refers to a situation that may exist in some individuals but not in everyone all the time; it is not usually observed in groups of human beings and in communities.

DEFINITION OF PUBLIC HEALTH

Public Health is…

- the science and art of preventing disease,
  - Prolonging life,
  - Promoting health and efficiency through organized community efforts for the sanitation of the environment.
  - The control of communicable infections/diseases.
  - The education of the individual in personal hygiene.
  - The organization of medical and nursing services for early diagnosis and preventive treatment of disease.
  - The development of social machinery to ensure for every individual a standard of living adequate for the maintenance of health.

So organizing these benefits as to enable every citizen to realize his birthright of health and longevity (The WHO Expert Committee on Public Health Administration 1952).

New Philosophy of Health

Health is ….

- a fundamental human right.
- the essence of productive life and decreasing expenditure on medical care.
- inter-sectoral.
- an integral part of development (e.g. Health as a abridge for peace).
- a central to the concept of quality of life.
- worldwide a social goal

Health involves individual, states and international responsibilities.
Health and its maintenance is a major social investment.

DIMENSION OF HEALTH

- Health is multidimensional.
- There are three specific dimension of health in WHO definition. These dimensions are physical, mental and social dimensions.
- Many more dimensions may be sited. E.g. spiritual, emotional, vocational, political etc.
- These dimensions function and interact with one another, each has its own nature.

a. Physical Dimension

- It implies perfect functioning of body.
- It conceptualizes health biologically as a state in which every cell and every organ is functioning at optimum capacity and in perfect harmony with the rest of the body.
- The signs of physical health in an individual are good complexion, clean skin, bright eyes, lustrous hair with a body well clothed with firm flesh, not too fat, a sweet breath, good appetite, sound sleep, regular activity of bowels and bladder and smooth, easy, coordinated bodily movement.
- All the organs of the body are of unexceptional size and function normally; all the special senses are intact; pulse, blood pressure etc. are within normal range for individual's age and sex.
- Biological normal limits are set by observation of large number of normal people who are free from evident disease.

b. Mental Dimension

- Mental health is defined as a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community.
- Mental health is not mere absence of mental illness or mental disease.
- A mentally healthy person has following **characteristics:**
  - He is free from internal conflicts; he is not at war with himself.
  - He is well adjusted i.e. he is able to get along well with others. He accepts criticism and not easily upset.
  - He searches for identity.
  - He has a strong sense of self-esteem.
  - He knows himself: his needs, problems and goal (i.e. self-actualization)
  - He has good self-control-balance rationality and emotionality.
  - He faces problems and tries to solve them intelligently, i.e. coping with stress and anxiety.

c. Social Dimension

- An individual is socially healthy if he is able to maintain harmonious relationship with other member of society in which he lives.
- Social health rooted in positive material environment" and positive human environment which is concerned with the social network of the individual.

The social dimension of health includes
(1)Communication (2) Intimacy (3) Respect (4) Equality (5) Social functioning

DETERMINANTS OF HEALTH

Health is multi-factorial.

Factors lie within the individual and externally in the society. Those factors interact and these interactions may be health promoting or deleterious. For conceptual purpose, health of individual and whole community may be considered to the results of many interactions.

As a brief, interactions of the more important influencing factors or determinants are described below. Determinants of Health (Factors influencing health) are

(1) Heredity
(2) Environment
(3) Lifestyle
(4) Socio-economic conditions
(5) Health and family welfare services
(6) Aging and the population
(7) Gender
(8) Other factors

The determinants of health include (WHO)

- the social and economic environment
- the physical environment, and
- the person's individual characteristics and behaviors.

The context of people's lives determine their health, and so blaming individuals for having poor health or crediting them for good health is inappropriate. Individuals are unlikely to be able to directly control many of the determinants of health. These determinants—or things that make people healthy or not— include the above factors, and many others:

- **Income and social status** - higher income and social status are linked to better health. The greater the gap between the richest and poorest people, the greater the differences in health.
- **Education** – low education levels are linked with poor health, more stress and lower self - confidence.
- **Physical environment** – safe water and clean air, healthy workplaces, safe houses, communities and roads all contribute to good health. Employment and working conditions – people in employment are healthier, particularly those who have more control over their working conditions.
- **Social support networks** – greater support from families, friends and communities is linked to better health. Culture - customs and traditions, and the beliefs of the family and community all affect health.
- **Genetics** - inheritance plays a part in determining lifespan, healthiness and the likelihood of developing certain illnesses. Personal behavior and coping skills – balanced eating, keeping active, smoking, drinking, and how we deal with life's stresses and challenges all affect health.
- **Health services** - access and use of services that prevent and treat disease influences health.
- **Gender** - Men and women suffer from different types of diseases at different ages.

About Determinants of Health

The range of personal, social, economic, and environmental factors that influence health status are known as determinants of health.

Determinants of health fall under several broad categories:

(1) Policymaking
(2) Social factors
(3) Health services
(4) Individual behavior
(5) Biology and genetics

It is the interrelationships among these factors that determine individual and population health. Because of this, interventions that target multiple determinants of health are most likely to be effective. Determinants of health reach beyond the boundaries of traditional health care and public health sectors; sectors such as education, housing, transportation, agriculture, and environment can be important allies in improving population health.

CHANGING CONCEPTS OF HEALTH

Understanding of health is the basis of health care services. It has evolved over the centuries as a concept from an individual concern to a worldwide social goal and encompassed the whole quality of life. In a world of continuous change new concepts are bound to emerge based on new patterns of thought.

a. Biomedical Concept

- Health has been viewed as "absence of disease".
- A person was considered healthy when he/she was free from disease.
- This concept was based on "germ theory of the disease" which dominated medical thought at the turn of 20th century.
- Medical Professional viewed the human body as a machine, disease as the consequence of the breakdown of the machine and the task of health professional is to repair the affected part.
- It has minimized the role of environmental, social, psychological and cultural determinants of health.
- This concept is inadequate to solve some of the major health problems of mankind.
  E.g. malnutrition, accidents, Non-communicable diseases, drug abuse, mental illness etc.
- Development of medical and social science led to conclude that the biomedical concept is inadequate.

b. Ecological Concept

- It viewed health as a dynamic equilibrium between man and his environment, and disease as a maladjustment of human to environment.
- Health is defined with a statement that "Health implies the relative absence of pain and discomfort, and a continuous adaptation and adjustment to the environment to ensure optimal function".
- The ecological concept raised two issues:
  - imperfect man and
  - imperfect environment.
- There is a strong argument that improvement in human adaptation to natural environment can lead to longer life expectancies and a better quality of life even in the absence of modern health delivery services.

c. Psychosocial Concept

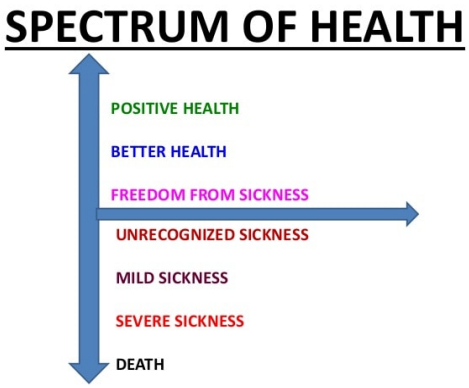
- Contemporary development in social science revealed that health is not only a biomedical phenomenon, and one which is influenced by social, psychological, cultural, economic and political factors of the people concerned.
- These factors must be taken into consideration in defining and measuring health.
- Thus, health is both biological and social phenomenon.

d. Holistic Concept

- This concept is the synthesis of all above concepts.
- It recognized the strength of social, economic, political and environmental influences on health.
- It has been variously described as a unified or multidimensional process involving the well-being of the whole person in the context of his environment.
- It corresponds to the view that health implies a sound mind, in sound body, in sound environment.
- Holistic approach implies that all sectors of society have an effect on health, in particular, agriculture, animal husbandry, food, industry, education, housing, public works, communication and other sectors.
- The emphasis is on the promotion and protection of health.

SPECTRUM OF HEALTH

- Health and disease lie along a continuum, and there is no single cut off point.
- The highest point corresponds to the positive health (optimum wellbeing) and the lowest point in the health-disease spectrum is death.
- Health fluctuates within a range of optimum wellbeing to various level of dysfunction including the state of total dysfunction i.e. death.
- The spectral concept of health emphasizes that the health of individual is not static; it is a dynamic phenomenon and a process of continuous change.
- A person may function at maximum level of health today, and diminished levels of health tomorrow.
- It implies that health is not attained once and forever.



IDENTIFICATION AND PRIORITIZATION OF HEALTH PROBLEMS

Introduction

Health workers working either in the community or at a health facility (e.g., hospital or rural health center) face the problems on a daily basis with limited resources (manpower, money & material) to solve problems. Therefore prioritization of the problems is needed to make efficient utilization of resources to achieve the desired objective.

A problem is a difficulty or obstacle seen to exist between a present situation and a desired objective in future. In other words, a problem is a perceived gap between what is and what should be.

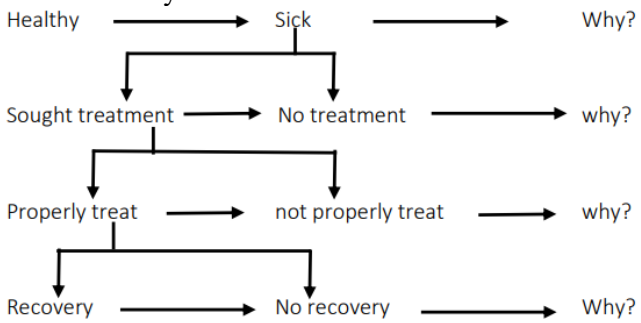
Identification of Health Problems

When identifying the problem, please go through the following steps:

- Define the problem
- Analyze the problem to find out all its possible causes

- Look for ways or solutions to remove these causes
- Make sure the problem is a disease or health problem, service problem, or community problem?
- Estimate/measure the magnitude of the problem.

Problem Analysis:



Prioritization of Health Problems

When prioritizing Health Problems, the following points should be considered.
The problem -

1. that has effect on the majority of population.
2. that affect mother and children.
3. that has high mortality.
4. that is a felt need or real need.
5. that is resources required and/or available.
6. that has a solution and can be solved with available resources.
7. that the community accept as a problem
8. that the community participate in solving it.

In addition, prioritization of health problems can be based on objective and subjective criteria.

- objective criteria include morbidity and mortality trend.
- subjective criteria include political concern, community concern, availability of preventive technology, socioeconomic impact etc.

A formula of Prioritization: $\text{Prioritization} = \frac{MIV}{C}$

M = Magnitude of the health problem affecting health status, i.e., morbidity, mortality, disability etc.;
I = Importance/extent of the problem, area, risk groups, impact of disease
V = Vulnerable to technology
C = Cost.

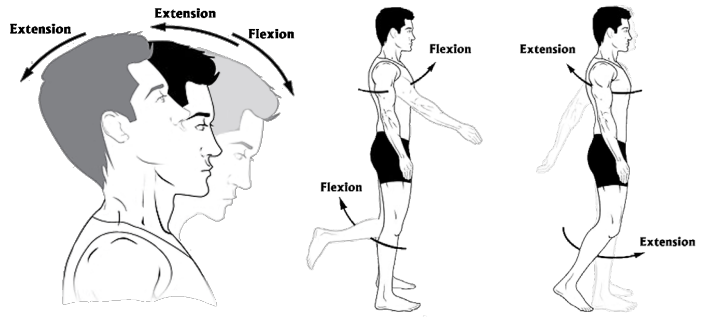
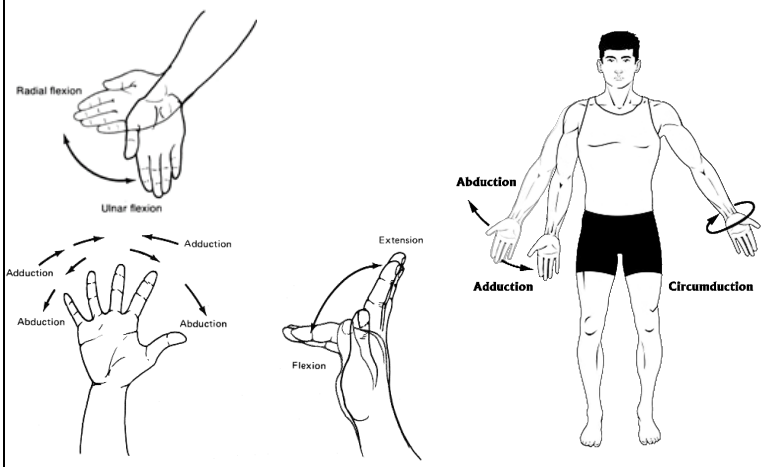
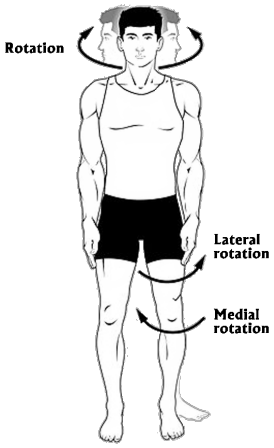
After identification, prioritization and analysis of health problems, a detailed action plan can be formulated or made based on identified plausible or possible solutions from the causal analysis. Scheduling of activities is needed, and once implemented it should be revised and updated whenever necessary through periodic monitoring, review and evaluation.

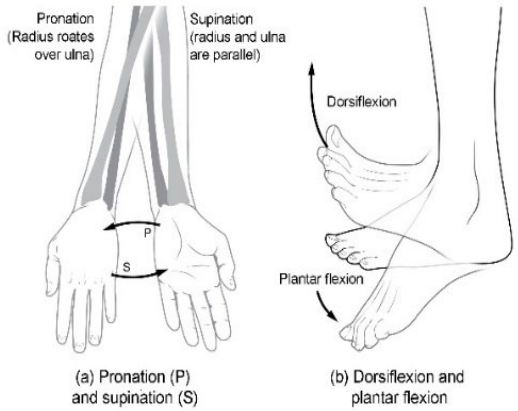
BASIC CONCEPTS AND TERMINOLOGY

Anatomy: the scientific study of the body and how its parts are arranged

Physiology: the study of the processes and function of the human body. Physiology is important because it is the base upon which we build our knowledge of what "life" is, and how to treat disease.

Terms of Movements

<table>
<tr><th>Movement</th><th>Terms</th></tr>
<tr><td> 
</td><td>Flexion
The act of bending or being bent
Extension
The movement that brings the parts of the limb towards a straight condition</td></tr>
<tr><td> 
</td><td>Abduction
Movement away from the midline
Adduction
Movement towards the midline
Circumduction
Movement of joints in a circular motion
Medial rotation
Rotating movement towards the midline.
Lateral rotation
Rotating movement away from the midline.</td></tr>
<tr><td> 


</td><td>Pronation
rotation of the palm of the hand or sole of the foot so the inner part faces down
Supination
the act of turning the palms of the hands or soles of the feet upward
Opposition
The ability to move the thumb into contact with the other fingers across the palm of the hand.
Inversion</td></tr>
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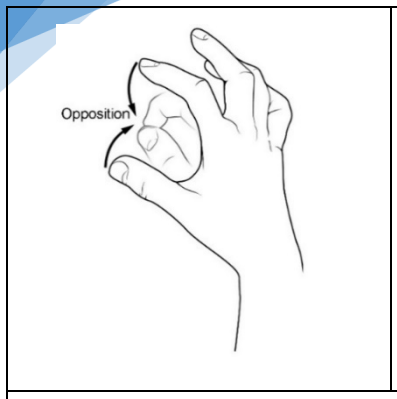
<td> 
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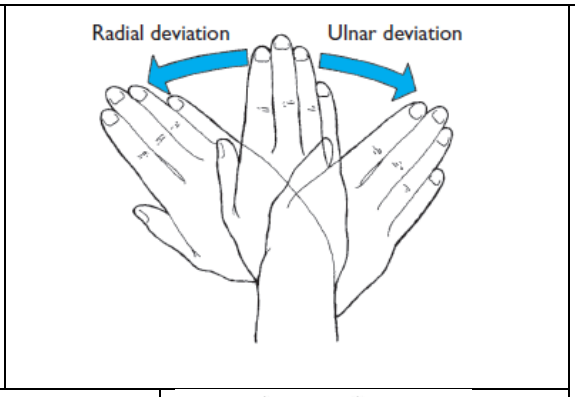
<td> 
</td>
<td rowspan="2">A turning inward, upside down, or in any direction contrary to the existing one.
Eversion
A turning inside out; a turning outward.
Radial deviation
Movement of the wrist toward the thumb side of the forearm

Movement of the wrist toward the little finger side of the forearm.
Elevation
Upward movement of a limb or body part
Depression
Movement in an inferior direction, the opposite of elevation
Protraction: Forward movement
Retraction: Posterior movement</td>
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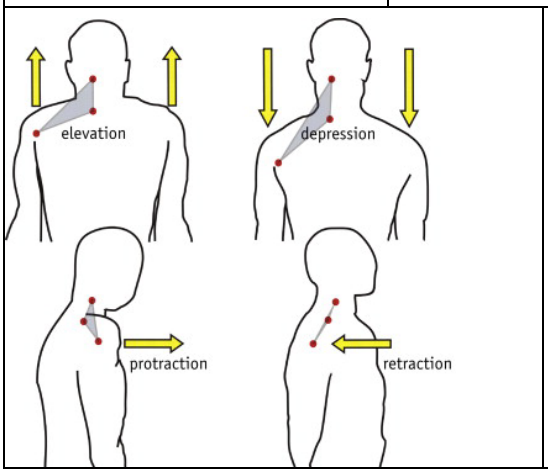
<td> 
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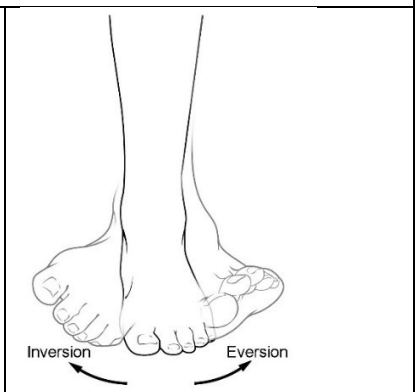
<td> 
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Terms of Direction

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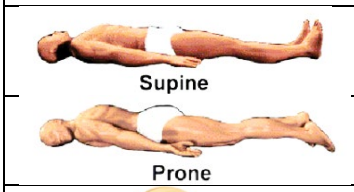
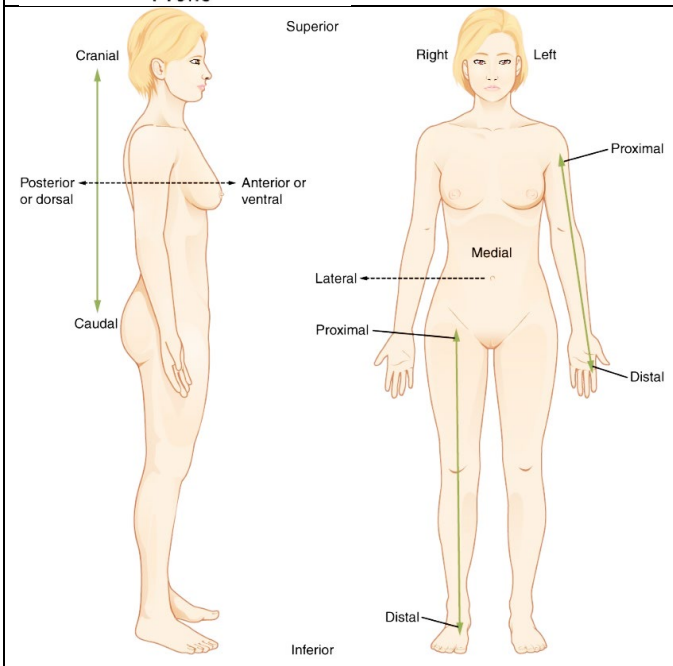
<tr><td rowspan="2"> 
</td><td>Lying flat on the back face up</td></tr>
<tr><td>Lying flat on the stomach face downwards</td></tr>
<tr><td> 
</td><td>Ventral or anterior
located on the front of the body

Dorsal or posterior
Located on the back of the body

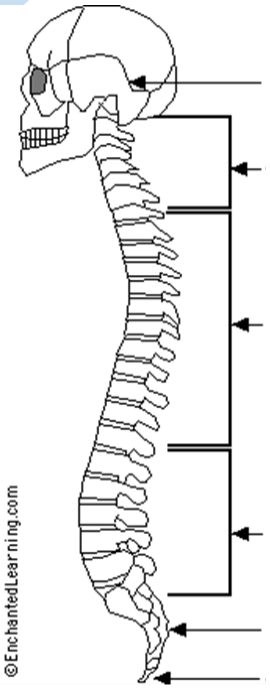
Medial
Through the center of the body

Lateral
Farther away from the center towards the side

Cranial
Toward the head

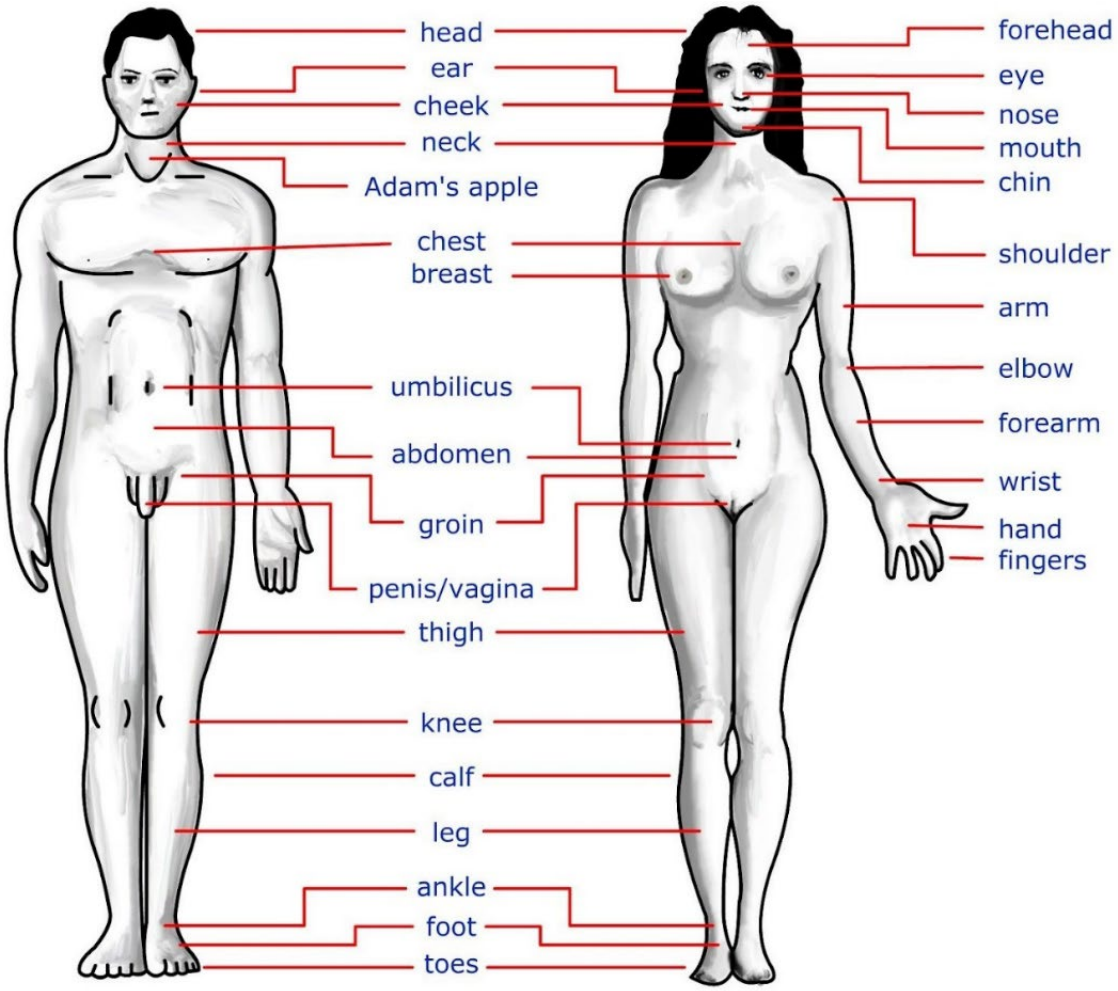
Caudal
Toward the distal end of the body</td></tr>
<tr><td>Proximal
Nearest to the trunk
Distal
Away from the center of the body</td><td>Superior
Situated above or directed upward
Inferior
Situated below or directed downward</td></tr>
</table>

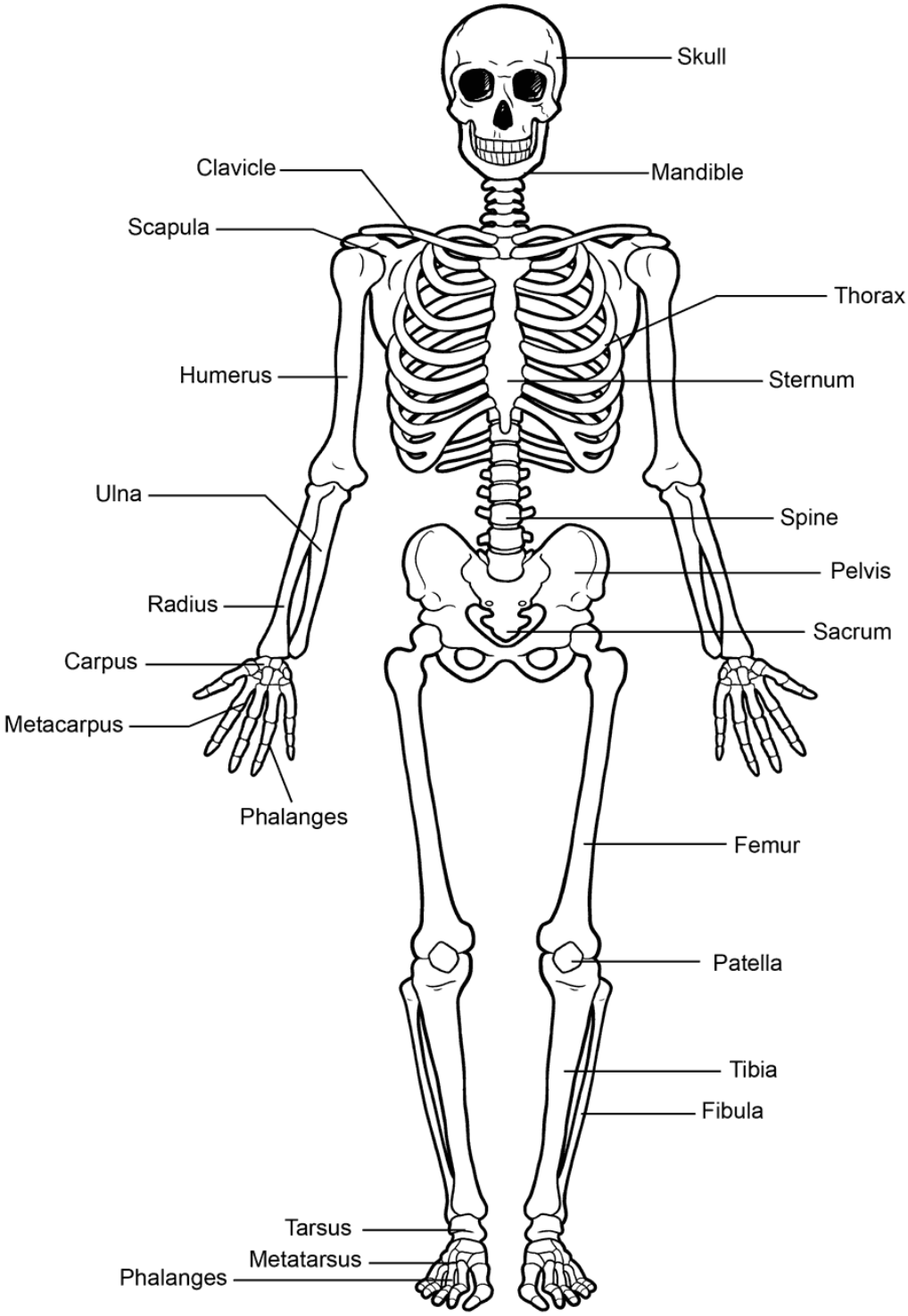
Spine and Skull

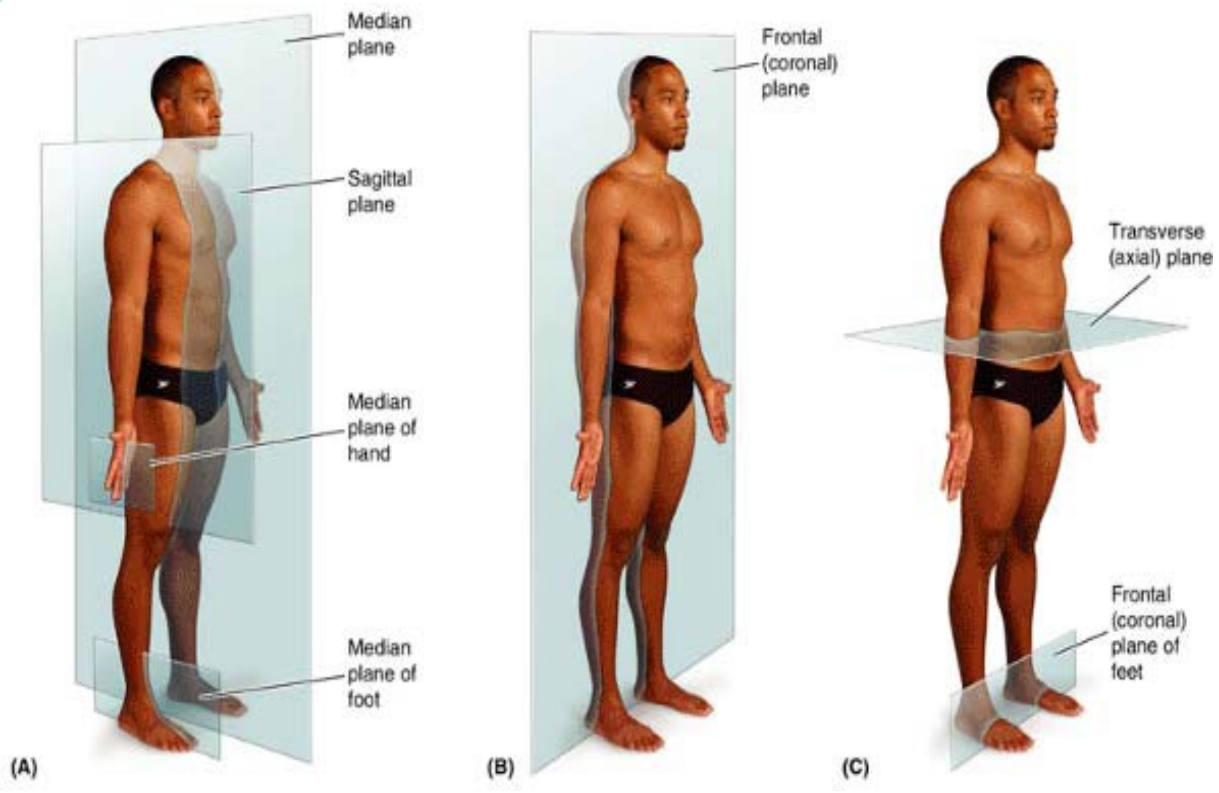


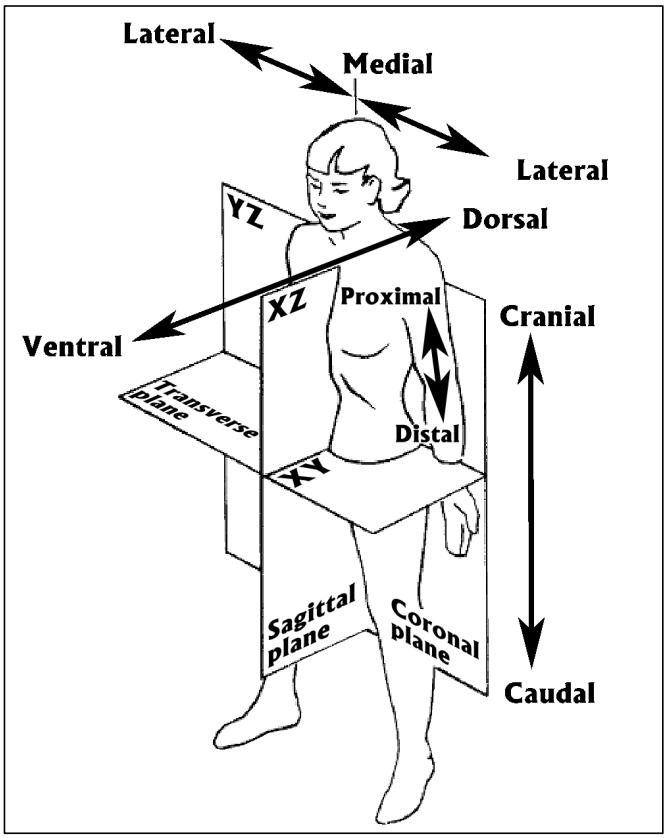
Skull - the bones in the head that protect the brain.
7 cervical vertebrae - 7 vertebrae located in the neck, below the skull.
12 thoracic vertebrae - 12 vertebrae in the mid-back, below the cervical vertebra and above the lumbar vertebrae.
5 lumbar vertebrae - 5 vertebrae located below the thoracic vertebra and above the sacrum.
Sacrum - 5 fused vertebrae located below the lumbar region and above the coccyx.
Coccyx - 4 fused vertebrae located below the sacrum.

External Human Body

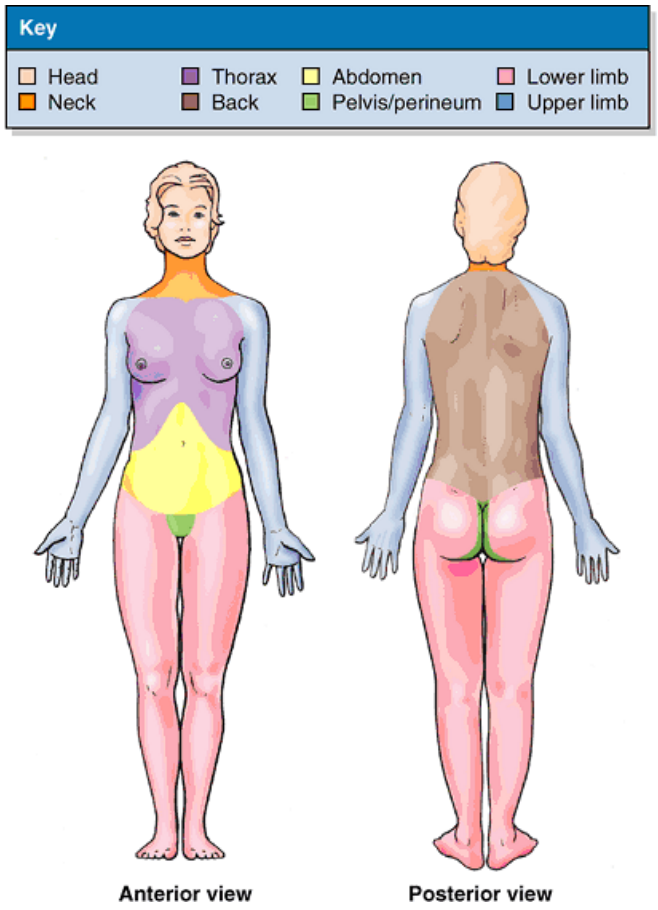


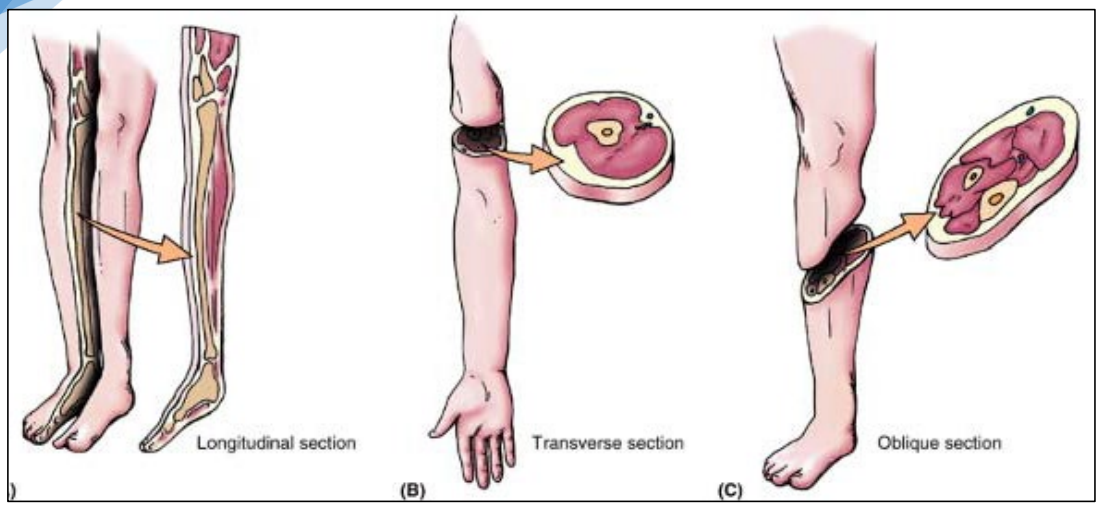




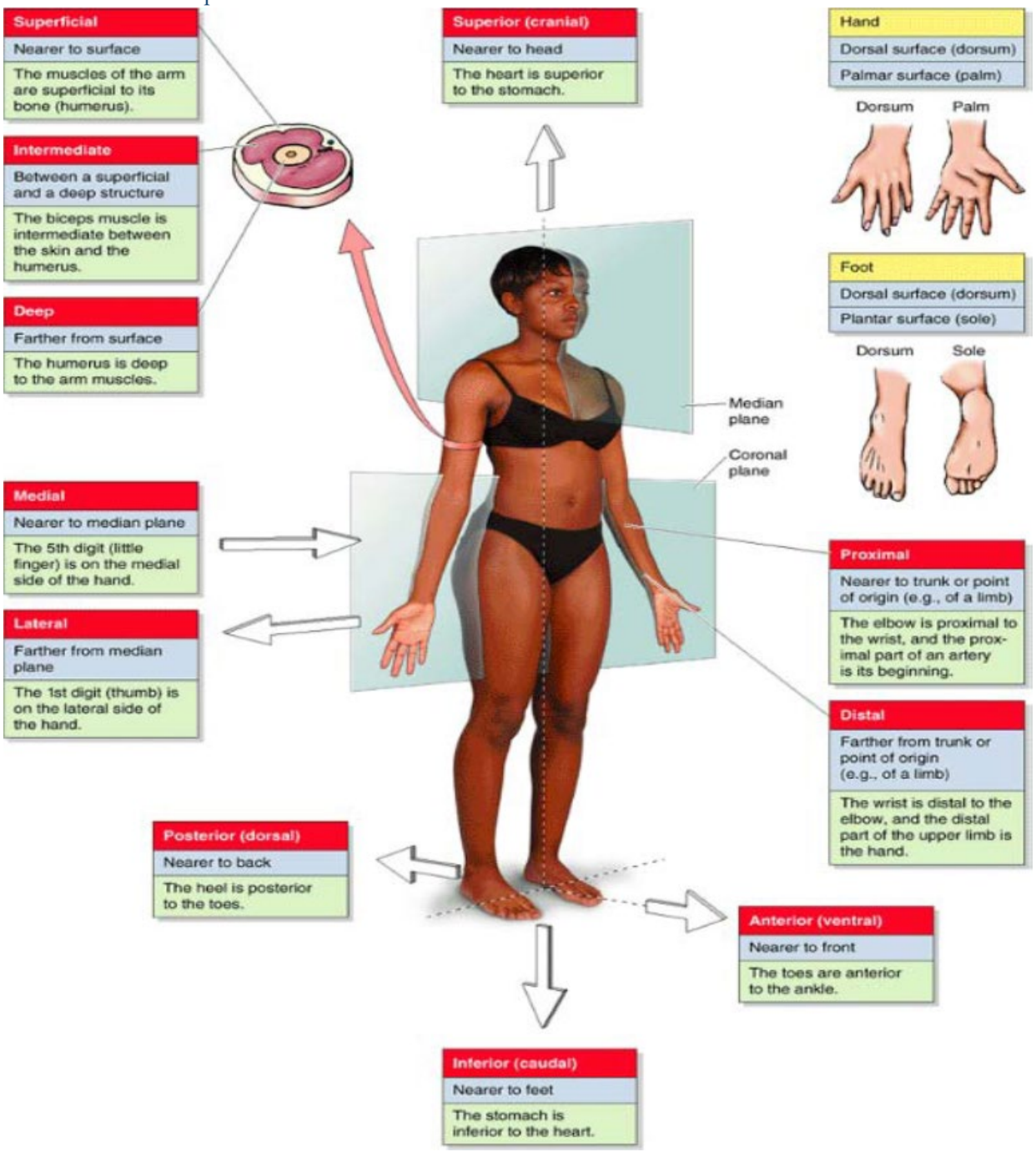


Anterior and Posterior Views





Terms of Relationships



CELLS AND SYSTEMS

The human body is a single structure, but it is made up of many smaller structures:

Cells

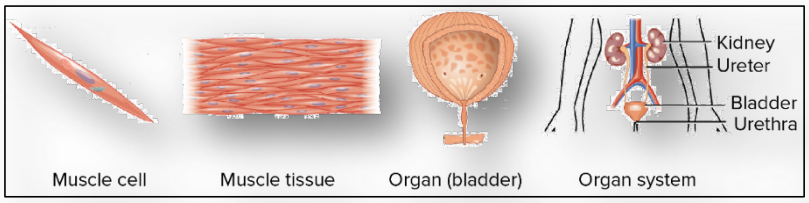
FORM

examples: fat cell, nerve cell, muscle cell, blood cell (each is an animal cell but each differs in structure ex. Muscle cells have more mitochondria)

Tissues

FORM

examples: epithelial, nerve, connective, muscle, blood



Organs

FORM

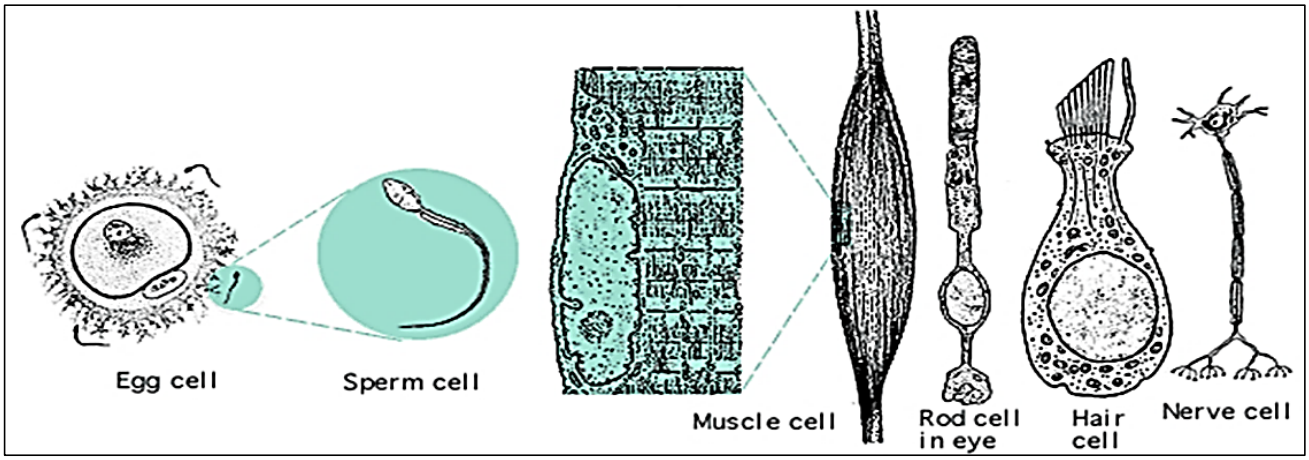
examples: heart, brain, esophagus, stomach, lungs, pancreas, glands

Organ Systems

examples: digestive, respiratory, excretory, circulatory endocrine, nervous

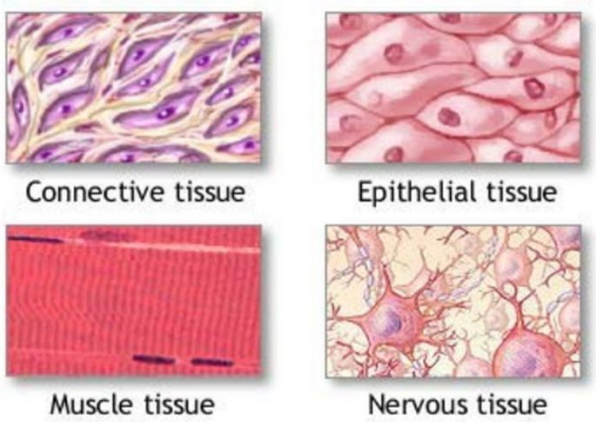
Cells

Cells are the smallest and simplest units of living matter that can maintain life and reproduce themselves (make copies). All living things are made up of one or more cells. Cells are the basic structural and functional units of the human body. There are many different types of cells (e.g., muscle, nerve, blood etc.)



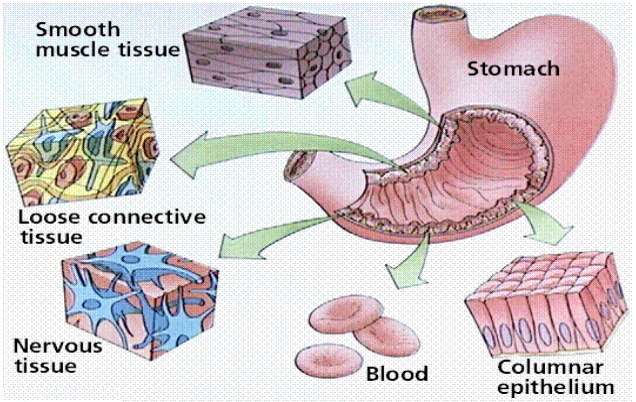
Tissues

Tissues are group of cells that perform a specific function with great organizing of similar cells with similar function. The basic types of tissues in the human body include epithelial, muscle, nerves, and connective tissues



Organs

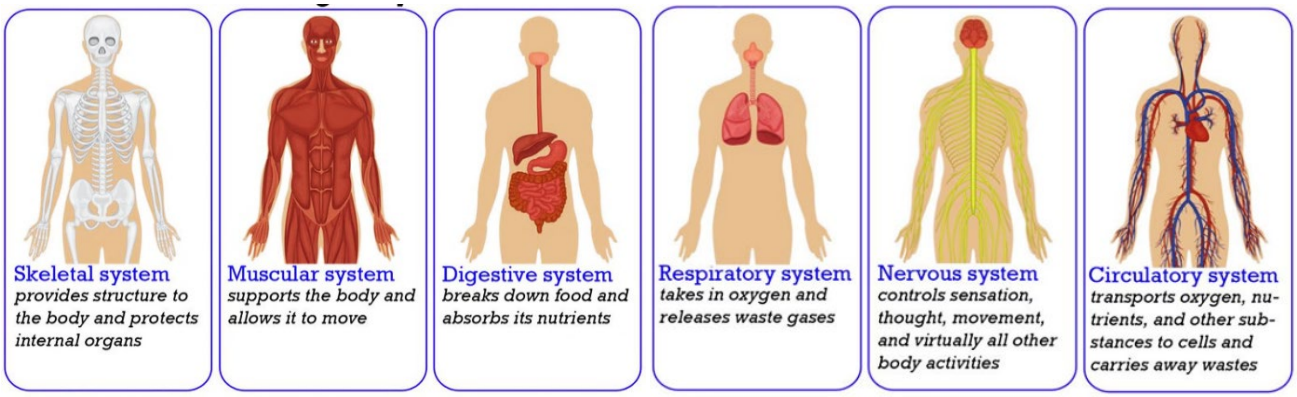
An organ is an organization of several different kinds of tissues so that it performs a special function. (E.g. heart, liver, stomach, etc.)



Systems

A system is an association of organs that have a common function.

The major systems in the human body include Respiratory system, cardiovascular system, Urinary system, Reproductive system, gastrointestinal (Digestive) system, Endocrine system, Nervous system, musculoskeletal system and Immune system.

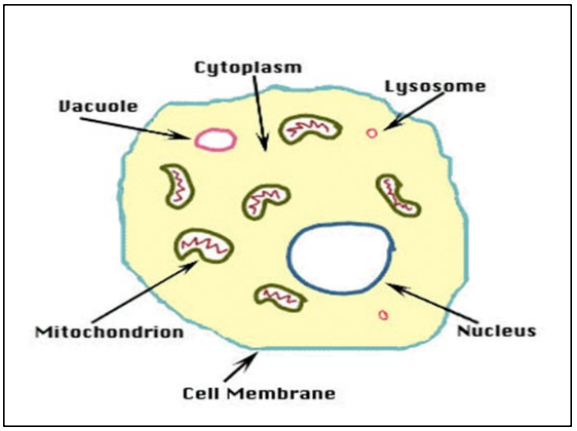


ORGANS AND SYSTEMS

The Cells

Cell Structure

The cell needs to get nutrients & oxygen in and waste products out. The interior of the cell is divided into nucleus and cytoplasm.



Cell membrane- is a barrier surrounding the cell.
Nucleus- is the center of most cells. Some contain multiple nuclei. It is responsible for transmitting genetic information.
Mitochondria- they are site of various chemical process in the synthesis of energy.
Lysosomes- contain highly acidic fluid which acts as digesting enzymes for breaking down bacteria and cell debris.
Vacuoles -might store food or any variety of nutrients a cell might need to survive. They can even store waste products, so the rest of the cell is protected from contamination.

Water Comprises 60 - 90% of typical cells ***Carbohydrates*** Comprise about 3% of the dry mass of a typical cell An important source of energy for cells (e.g., glucose) ***Fat/ lipids*** Comprise about 40% of the dry mass of a typical cell Its function is for energy storage and "messengers" (hormones) that play roles in communications within and between cells ***Proteins*** Are about 50 - 60% of the dry mass of a typical cell Subunit is the amino acid Main functions – form the structure of a cell, antibody, (E.g., Immunoglobin G (IgG)) transport/storage, enzymes and messengers (E.g., hormones)	Cells are constantly working to stay alive. Different types of cells have different function. Food molecules are changed into material needed for energy, and substances which are needed for growth and repair Cellular metabolism is the sum of all chemical changes that take place in a cell which requires energy. Cells require energy to carry out their basic function. For example, digestion, breathing in and out, exercise etc. require energy.

Energy

Cells can produce their own energy. The energy comes from the food we eat (carbohydrates, proteins, fats). Before food can be processed into energy, large substances (molecules) must be broken down into their basic units. This step is known as digestion. Most of digestion takes place in the digestive tract (GIT) of humans

Complex Food Molecule	**Basic Units**
Proteins	Amino Acids
Carbohydrates	Simple Sugars (e.g., glucose)
Fats (Lipids)	Fatty Acids and Glycerol

An important source of energy for cells is glucose.
Glucose + oxygen (O_2) ----------> CO_2 + H_2O + ENERGY
Fats and proteins are also metabolized to produce energy.
Cells must be able to produce, store energy & release that energy in appropriate amounts when needed.

CARDIOVASCULAR SYSTEM

The cardiovascular/circulatory system transports food, hormones, metabolic wastes, and gases (oxygen, carbon dioxide) to and from cells. Components of the circulatory system include:
(1) Blood (2) Heart (3) Blood Vessels

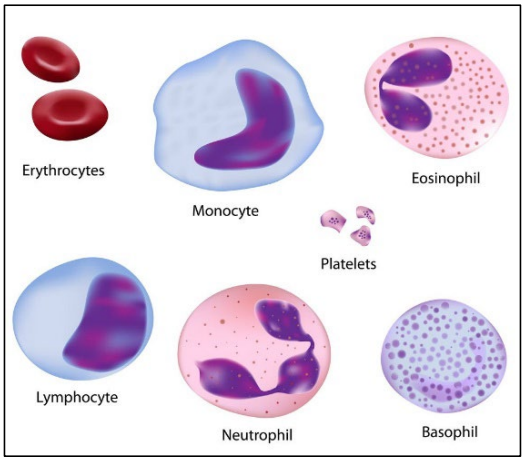
Blood

Blood is composed of about 60% plasma and 40% cells. The total blood volume for an adult is about 5 liters. The blood which is carried by arteries is called arterial blood, and the blood which is carried by veins is called venous blood. **Plasma** is a yellowish liquid containing water, proteins, and electrolytes (salts). The cells of blood are **red blood cells** (erythrocytes), **white blood cells** (leucocytes) and **platelets**. The blood cells are produced in the bone marrow.

Red blood cells (RBC) give the blood's characteristic red color due to hemoglobin. Hemoglobin is a compound responsible for transporting oxygen.

White blood cells (WBC) are a variety of cells that help to defend the body against infections.

Platelets help to initiate blood clotting to repair damaged blood vessels.



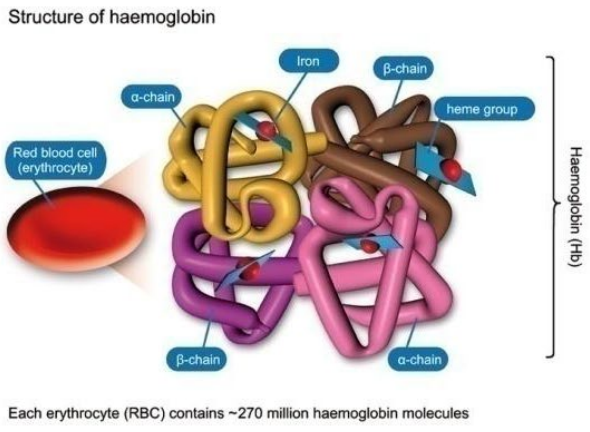
Physiology of Blood

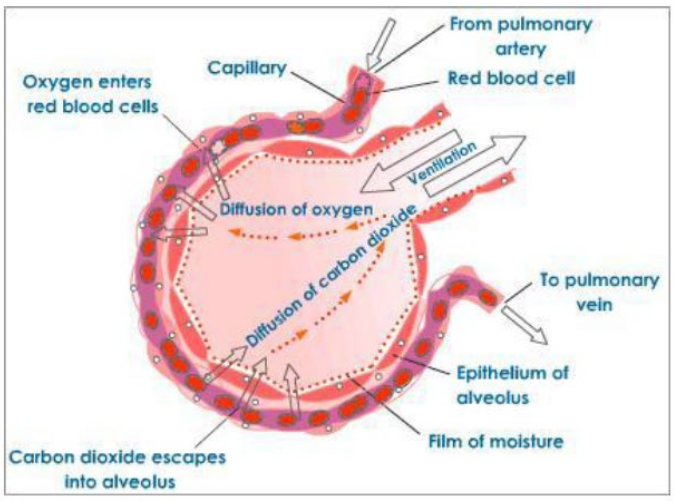
The blood has three main functions: transport, regulation and protection.

Transports	Regulates	Protects
▪ Oxygen from the lungs to the cells ▪ Carbon dioxide from the cells to the lungs ▪ Nutrients from the intestine to the cells ▪ Waste material from the cells ▪ Hormones from the endocrine glands to the cells ▪ Heat from various cells	▪ Body temperature ▪ Salts and water content in the cells	▪ Blood prevents its loss by clotting and combats toxins.

Hemoglobin

Hemoglobin (Hb) is the iron-containing protein attached to red blood cells that transports oxygen from the lungs to the rest of the body.
Hemoglobin is made up of four subunits (Alpha 1, 2 & Beta 1, 2) with a haem (iron-containing) group in each for oxygen binding.
Hemoglobin abnormalities result in very serious hereditary diseases, such as sickle-cell anemia and thalassemia.



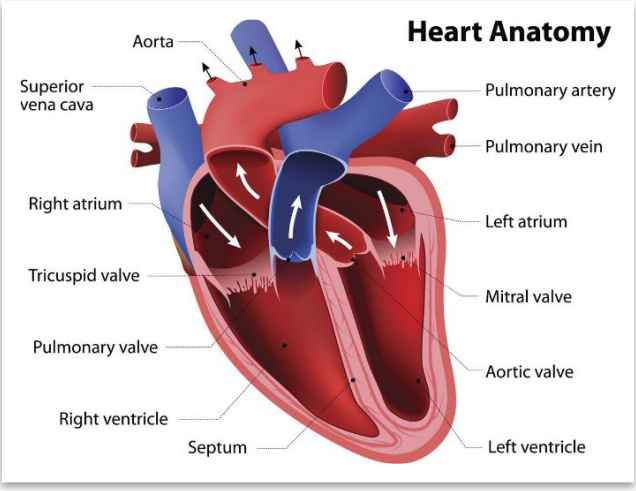


Function of Hemoglobin

Hemoglobin bonds with oxygen in the lungs, exchanges it for carbon dioxide at cellular level, and then transports the carbon dioxide back to the lungs. Whether hemoglobin binds with oxygen or carbon dioxide, depends on the relative concentration of each around the red blood cell. When it reaches the oxygen-rich lungs, it releases the less-abundant carbon dioxide to bind with oxygen and then, CO2 is exhaled through lungs. When it goes back out into the body where cells are producing carbon dioxide, it releases the oxygen to bind with carbon dioxide and then, O2 is supplied to the cells.

Heart

The heart is the pump responsible for maintaining adequate circulation of oxygenated blood around the vascular network of the body.



Anatomy of the Heart

- Located between the lungs, two-thirds of it lies left of the chest midline.
- The heart is about the size of a man's fist. Internally, the heart is divided into four hollow chambers, two on the left and two on the right.
- The upper chambers of the heart, the atria, receive blood via veins. Passing through atrioventricular valves, blood then enters the lower chambers, the ventricles.
- Ventricular contraction forces blood into the arteries.

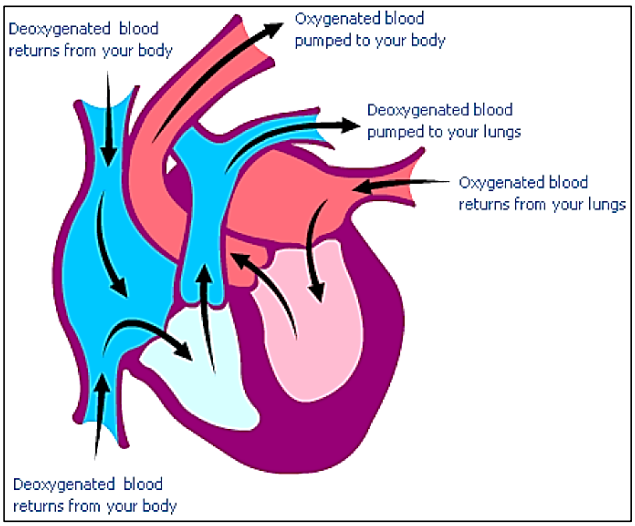
Valves in the Heart

- Between each pair of chambers are valves (windows) and preventing any back flow of blood.

1. The mitral valve - between the left atrium and the left ventricle.
2. The tricuspid valve - between the right atrium and the right ventricle.
3. The pulmonary valve - between the right ventricle and the pulmonary artery (the main artery that takes blood from the heart to the lungs to collect oxygen).
4. The aortic valve - between the left ventricle and the aorta (the main artery that takes oxygen-rich blood from the heart to the body).

Pulmonary Circulation

- Oxygen-poor blood empties into the right atrium via the superior and inferior vena cava.
- Blood then passes through the tricuspid valve into the right ventricle which contracts, forces the blood into the pulmonary artery, which branches to the right and left lungs.
- There, gas exchange occurs-carbon dioxide diffuses out, oxygen diffuses in.



Systemic Circulation

- Pulmonary veins now carry the oxygenated blood from lungs to the left atrium of the heart.
- Blood passes through the mitral valve into the left ventricle. The ventricle contracts and sending blood through the aorta.
- The ascending aorta carries blood to the upper body, the descending aorta, to the lower body.

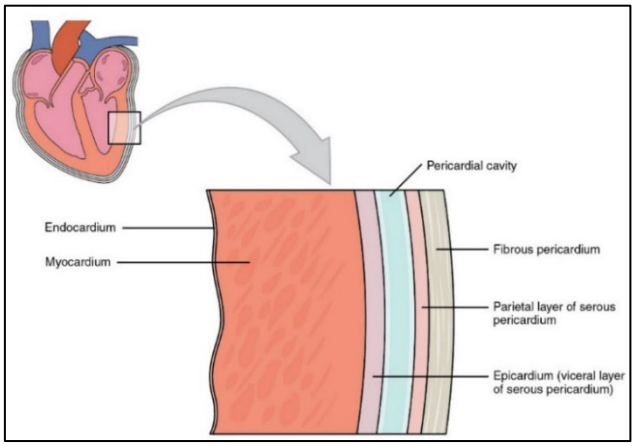
The Coronary Circulation (Blood Supply of the Heart)

- The heart needs its own reliable blood supplying or due to keep beating.
- The important part of the systemic circulation is the coronary circulation, which supplies the heart muscles with blood.
- They have a very small diameter and may become blocked, producing a heart attack.

Heart Wall

The wall of the heart is composed of 3 parts.

(1) Pericardium
(2) Myocardium
(3) Endocardium



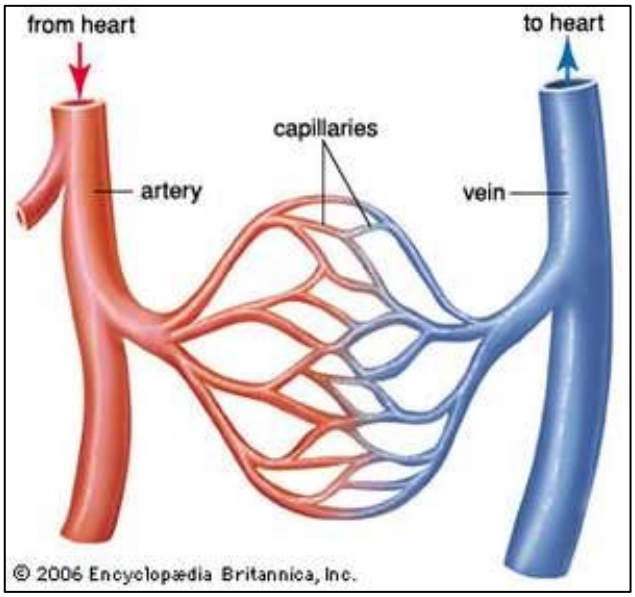
The pericardium is the external part (outside) of the heart and his function is to protect the heart. And the pericardium contains the vessels and the nerves of the heart: it means the coronary arteries, the coronary veins, the lymph vessels and the nerves.

The myocardium is in the middle of the wall, it is a very thick muscle, and it is this muscle that permits the pumping action of the heart.

The Endocardium is inner part of the heart wall. It is a very thin sheath on the internal surface of the heart, in the 4 chambers and also continues with the internal sheath of the vessels called endothelium of the vessels. When you have an endocarditis, you have an infection of the endocardium.

Vascular System - Blood Vessels

- Arteries, veins, and capillaries comprise the vascular system.
- Arteries and veins run parallel throughout the body with a web-like network of capillaries connecting them.
- Arteries are controlled by the cardiac conduction system and veins are controlled by the muscular contraction.



Arteries

- Arteries divide into progressively thinner tubes and eventually become fine branches called arterioles.
- Blood in arteries is oxygen-rich.
- The aorta is the largest artery in the body, the main artery for systemic circulation.

Capillaries

- The arterioles branch into the microscopic capillaries, or capillary beds, which lie in interstitial fluid, or lymph produced by the lymphatic system.
- Capillaries are the points of exchange between the blood and surrounding tissues.

Veins

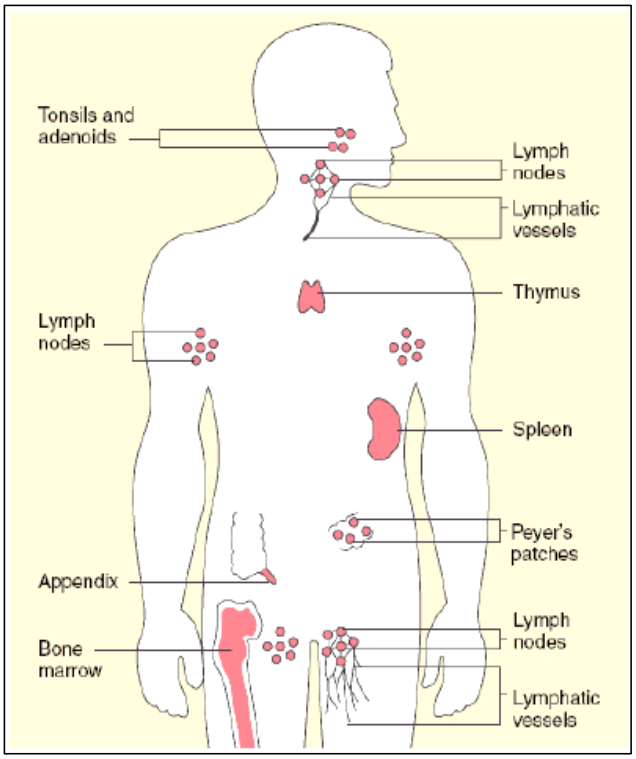
- Blood leaving the capillary beds flows into a series of progressively larger vessels, called venules, which in turn unite to form veins.
- Veins are responsible for returning blood to the heart after the body cells exchange gases, nutrients and wastes.
- Blood in veins is oxygen-poor.
- Pressure in veins is low, so veins depend on nearby muscular contractions to move blood along.
- Veins have valves that prevent back-flow of blood.

Lymphatic

It consists of a moving fluid (lymph/interstitial fluid); vessels (lymphatic); lymph nodes, and organs (bone marrow, liver, spleen, and thymus).

Capillaries release excess water and plasma into intracellular spaces, where they mix with lymph, or interstitial fluid.

"Lymph" is a milky body fluid that also contains proteins, fats, and a type of white blood cells, called "lymphocytes," which are the body's first-line defense in the immune system.



Functions

- To absorb excess fluid, thus preventing tissues from swelling.
- To defend the body against microorganisms and harmful foreign particles
- To facilitate the absorption of fat (in the villi of the small intestine).

Cardiac conduction

- Regular, rhythmic contraction and relaxation of the heart is maintained by electrical impulses which are spread through the heart by a specialized conduction system

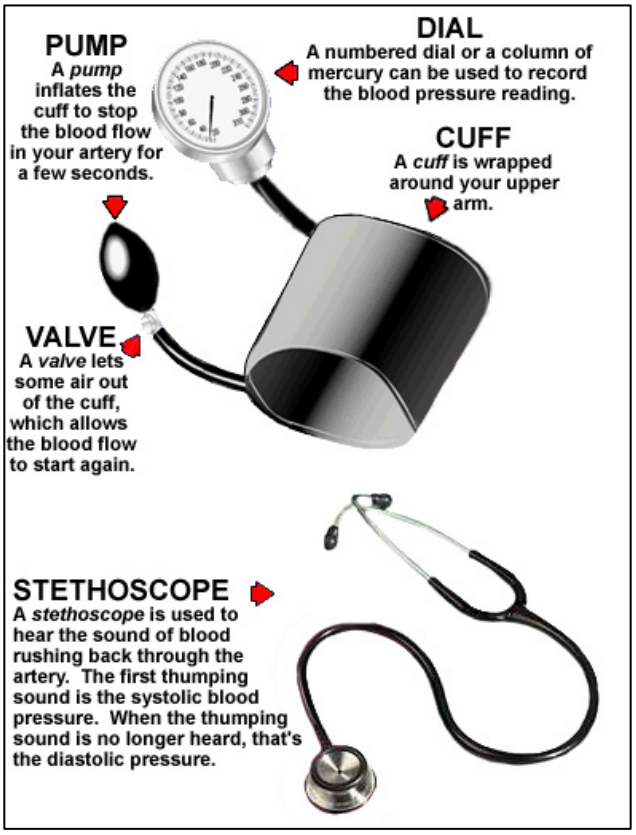
Heart rate

The heart beats or contracts around 70 times per minute.

- One heartbeat, or cardiac cycle, includes atria contraction and relaxation, ventricular contraction and relaxation, and a short pause.
- Atria contract while ventricles relax, and vice versa.
- Heart valves open and close to limit flow to a single direction. The sound of the heart contracting and the valves opening and closing produces a characteristic "lub-dub" sound.

Blood pressure

- The cardiac cycle consists of two parts: systole (contraction of the heart muscle in the ventricles) and diastole (relaxation of the ventricular heart muscles).
- When the ventricles contract, they force the blood from their chambers into the arteries leaving the heart.
- The left ventricle empties into the aorta and the right ventricle into the pulmonary artery. The increased pressure on the arteries due to the contraction of the ventricles (heart pumping) is called systolic pressure. The systolic pressure is at its highest force.
- When the ventricles relax, blood flows in from the atria. The decreased pressure due to the relaxation of the ventricles (heart resting) is called diastolic pressure.



Factors influencing Blood Pressure

- Heart rate- if the heart beats very fast the heart muscle cannot work effectively
- Volume of the blood- the blood pressure falls when the volume is low, and the blood pressure will rise if the volume of blood increases
- If the blood vessels narrow the blood pressure will rise
- If the blood vessels widen the blood pressure will fall

Physiological facts influencing Blood Pressure

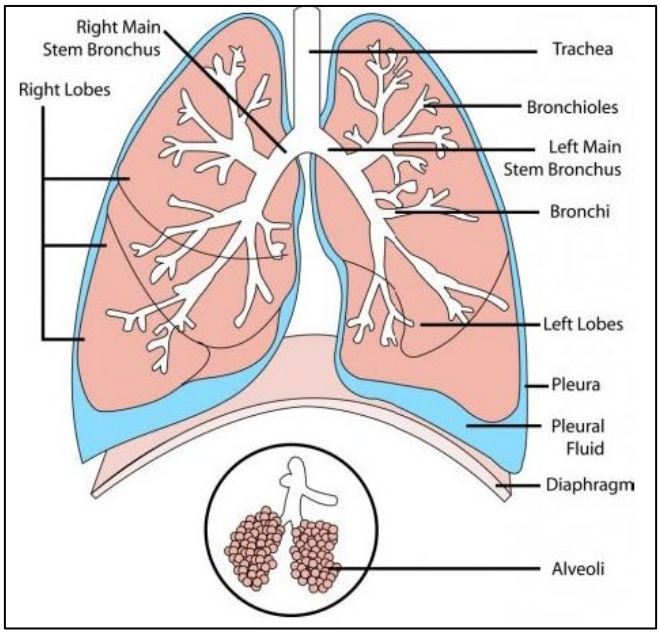
- Salt increases the body's need for water. Increased intake of salt and water will lead to an increase in volume and an increase in blood pressure

There are many factors that will control blood pressure. Two examples are,

- There are receptors in the brain and two important arteries
- Hormones such as adrenaline can put the blood pressure up
- The units of measurement are millimeters of mercury (mm Hg). For example, 120 mm Hg/80 mm Hg is considered to be normal blood pressure. The piece of equipment used to measure blood pressure is called a sphygmomanometer.

RESPIRATORY SYSTEM

The respiratory system is situated in the thorax and is responsible for gaseous exchange between the circulatory system and the outside world.



Bronchial tree - the system of airways within the lungs, which bring air from the trachea to the lung's tiny air sacs (alveoli).
Cardiac notch - the indentation in the left lung that provides room for the heart.
Diaphragm - a muscular membrane under the lungs.
Larynx - a muscular structure at the top of the trachea, containing the vocal cords.
Left inferior lobe - the bottom lobe of the lung on the left side of the body.
Left superior lobe - the top lobe of the lung on the left side of the body.
Right inferior lobe - the bottom lobe of the lung on the right side of the body.
Right middle lobe - the middle lobe of the lung on the right side of the body.
Right superior lobe - the top lobe of the lung on the right side of the body.
Trachea (windpipe) - the tube through which air travels from the larynx to the lungs.

The respiratory system can be divided in 2 sections:

1. **The upper respiratory tract** includes the nasal cavity and pharynx and larynx.
2. **Lower respiratory tract i**ncludes trachea, bronchi, bronchioles, alveoli and lungs.

Upper Respiratory Tract

Nose (Nasal Cavity)

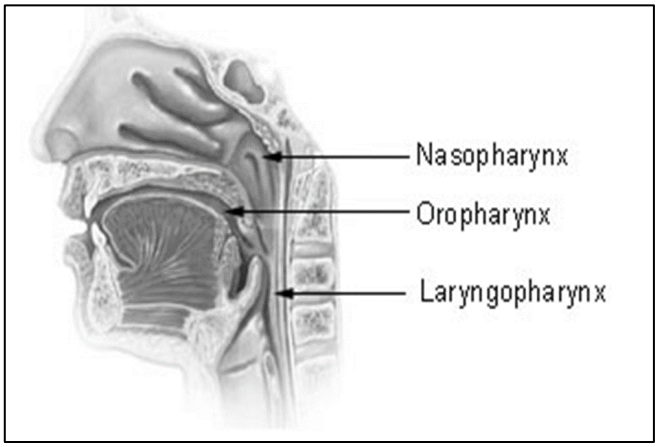
- The surface of the inside of the nose is covered by nasal epithelium that serves to warm, make wet and clean the air
- In the nose, you have the holes of the sinus (frontal, maxillary, ethmoidal and sphenoid sinus). The sinus is cover by a mucosa.

Pharynx

It is divided in 3 parts

(1) **Nasopharynx** (nasal part of the pharynx) - just behind the nose, communicate with the auditory tube from the ear.
(2) **Oropharynx** (oral part of the pharynx) - which receives the air and the food from the mouth.
(3) **Laryngopharynx** - just before the separation between the digestive tract (fluid and food go in the esophagus) and the respiratory tract (air goes in the larynx, first part of the lower respiratory tract).

- There are pharyngeal tonsils (adenoids) which protect from infection (see immune system).



Lower Respiratory Tract

Larynx

The larynx is a short tube located between base of tongue and the trachea. The Adam's apple is the prominence of the larynx cartilage. In the front, outside the respiratory tract, there is the thyroid gland

Function:

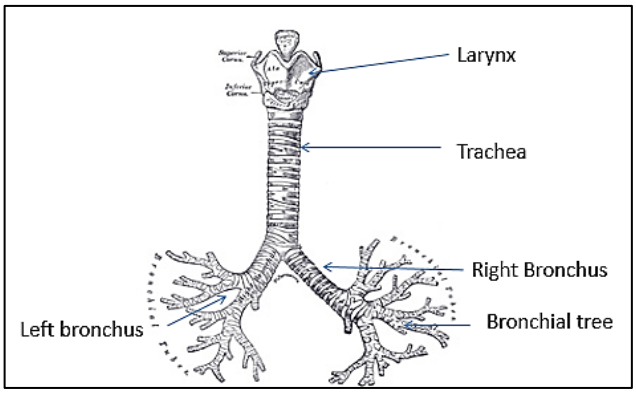
- To avoid the food and the fluid go in the lungs during the swallowing and to permit the passage of the air during the breathing.
- To produce the sound with the vocal cords.

Trachea

It is the tube (12 cm long and diameter 2.5 cm) between the larynx and the bronchi. The trachea is situated in front of the esophagus in the thorax. The trachea is covered by a mucosa. The trachea is composed by cartilage rings.

Function:

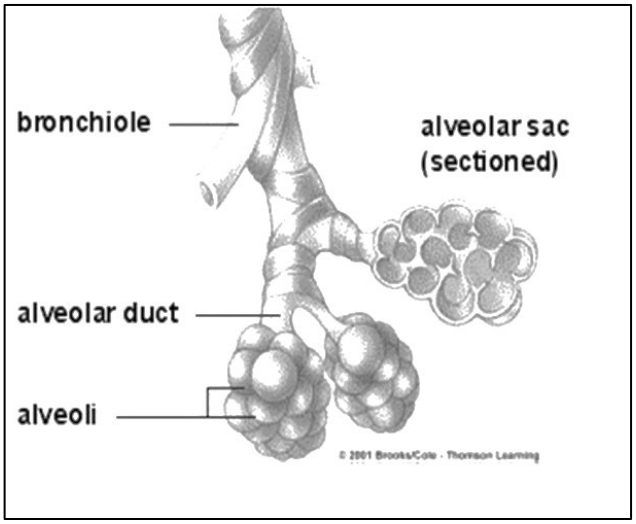
- To maintain open the tube for the passage of the air.



Bronchial Trees

There are 2 main **bronchi**: the right and left

- The right bronchus goes in the right lung and the left bronchus goes in the left lung.
- The structure of the bronchi is composed of cartilage rings to form opened tubes
- From the main bronchi, the bronchi are divided into more and more small bronchi, until the smallest bronchi called **bronchioles**, which arrive in the **alveoli.**



Bronchioles

- The smallest bronchi which connect with the alveolar duct and the alveoli
- There is no cartilage on the wall of the bronchioles. There are muscles which permit the opening and closing of the bronchioles.

Alveoli ducts and alveoli

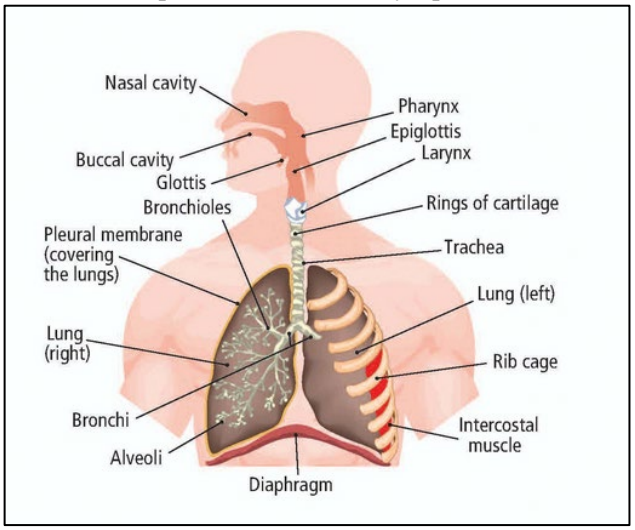
- Are small tubes found at the end of the bronchioles,
- Each bronchiole gives air to few alveoli together situated in a bag called alveoli sacs.
- The gas exchanges occur across the wall of the alveoli.
- Surfactants are proteins produced by the alveoli cells, which helps the alveoli to stay open when the air arrives.

Lungs Anatomy

The lungs are spongy-paired organs situated in the thorax. They are separated with the heart and the others organs (situated in the middle of the thorax) by a double sheet called mediastinum. The right and left lungs are separated by the mediastinum.

The lungs are divided into lobes

- The left lung is composed of the upper lobe, the lower lobe and the lingual (a small remnant next to the apex of the heart)
- The right lung is composed of the upper, the middle and the lower lobes.



The pleurae is composed by 2 sheets

- The external sheet in contact with the ribs is called parietal pleura
- The internal sheet in contact with the lungs is called visceral pleura.
- In the middle of these 2 sheets, you have a cavity called pleural cavity and this cavity contain a thin lubricating fluid produced by the pleurae.

Function:

- Protect the lungs and also stick the lungs on the ribs. Then the lungs can expand with the movements of the thorax.

Physiology of Respiratory System

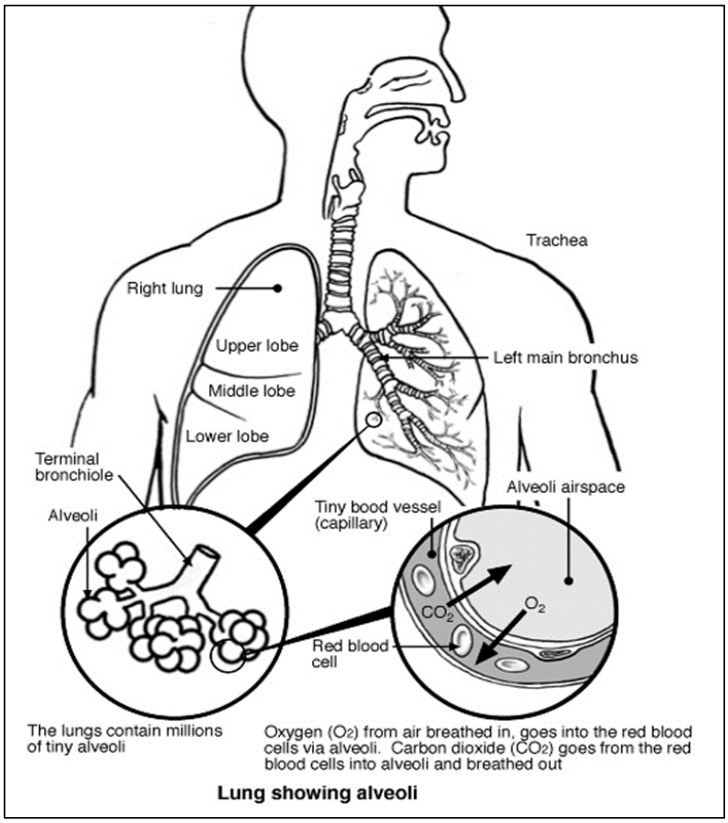
Components of respiration includes: (1) Ventilation (2) Gas exchange (3) Oxygen Utilization

Ventilation

- **Inspiration** is a process of breathing in. To take a breath in, the external intercostal muscles contract, moving the rib cage up and out.
- The diaphragm moves down at the same time, creating negative pressure within the thorax.
- The lungs are held to the thoracic wall by the pleural membranes, and so expand outwards as well. This creates negative pressure within the lungs, and so air rushes in through the upper and lower airways.
- **Expiration** is mainly due to the natural elasticity of the lungs, which tend to collapse if they are not held against the thoracic wall.

Gas Exchange

- Each branch of the bronchial tree eventually sub-divides to form very narrow terminal bronchioles, which terminate in millions of alveoli in each lung, and these are the areas responsible for gaseous exchange, presenting a massive surface area for exchange.
- Each alveolus is very closely associated with a network of capillaries. Their walls are very thin, allowing rapid exchange of gases by passive diffusion along concentration gradient.
- CO2 moves into the alveolus as the concentration is much lower in the alveolus than in the blood,
- O2 moves out of the alveolus and enter the blood through the capillaries.
- Disorders effect gas exchange: Pneumonia, Tuberculosis and Emphysema



Lung showing alveoli

Oxygen Utilization

- **Oxygen utilization** by the tissues when the cells use the oxygen during the cell metabolism (see cellular metabolism)

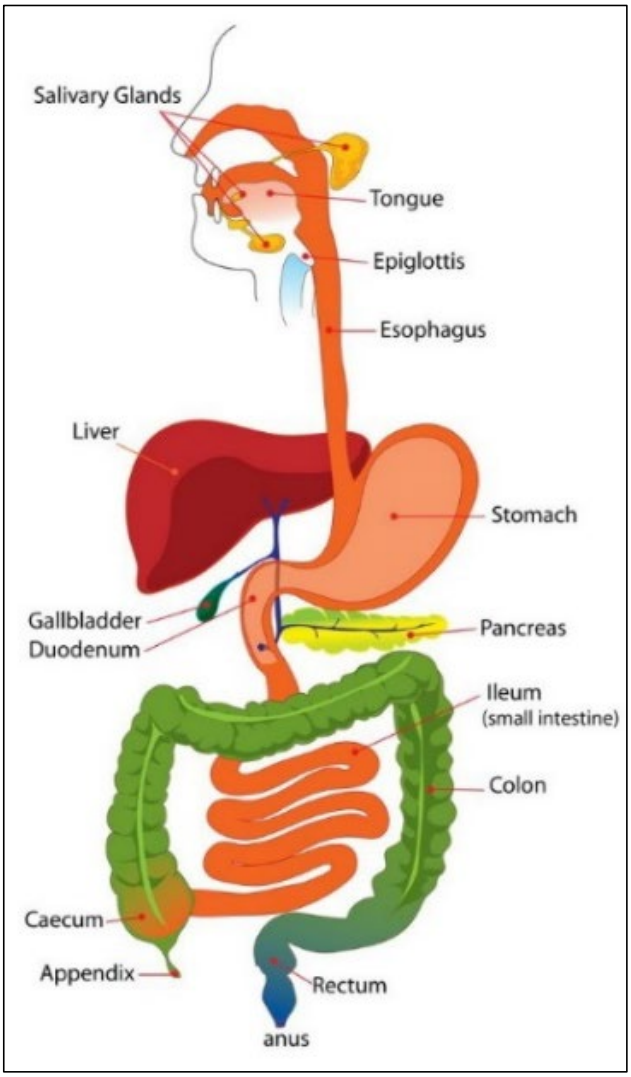
GASTROINTESTINAL SYSTEM

The gastro-intestinal system is essentially a long tube running right through the body, with specialized sections that are capable of digesting material. And extracting any useful components from it, and then expelling the waste products at the bottom end.

The whole system is under hormonal control, with the presence of food in the mouth triggering off a hormonal action; when there is food in the stomach; different hormones activate acid secretion, increased gut motility, enzyme release.

Once food has been chewed and mixed with saliva in the mouth, it is swallowed and passes down the esophagus. The esophagus secretes mucus from mucous glands, which aid the passage of food down the esophagus. The lumen of the esophagus propels food into the stomach by waves of peristalsis.

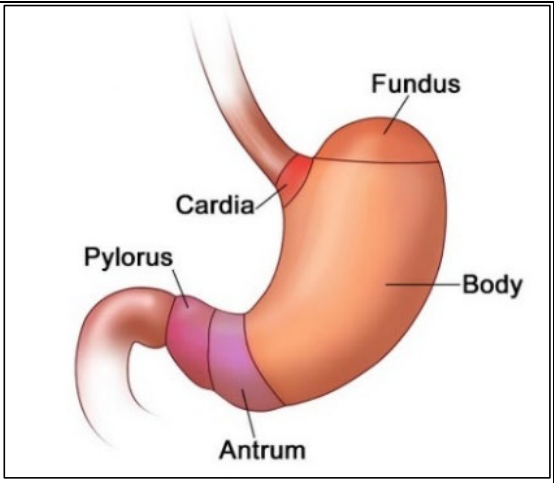
Nutrients from the GI tract are taken to the liver to be broken down further, stored, or distributed.



Components and Functions of GI Tract

Mouth (oral cavity)	Tongue, teeth, palate and salivary glands
	Functions
	• **Ingestion** is a process of taking food into the mouth.
	• Initiation of the digestion of sugar (carbohydrates) by saliva (from salivary glands) which contains amylase enzyme
	• **Swallowing** is the process by which food pass from the mouth to the esophagus. The swallowing process has three stages:
	  ○ The oral stage (in the mouth)
	  ○ The pharyngeal stage (in the throat)
	  ○ The esophageal stage (in the esophagus).

Pharynx (throat)	Crossroads between nasal and oral cavities-trachea and esophagus Functions • During swallowing the larynx lifts up to meet the epiglottis and seal/cover the trachea to prevent food from entering the trachea. • Choking is a reflex action when food or liquid passes into the trachea; it involves a sudden forceful expulsion of air through the larynx to clear the airway
Esophagus	The esophagus is a muscular tube of approximately 25cm in length and 2cm in diameter. Function: • Transport bolus to the stomach by peristalsis, like waves • Prohibits backflow (reflux) from the stomach by the lower esophageal sphincter: After food pass in the stomach, constriction. • If weakness of the sphincter, reflux of acid gastric juices → burning pain behind the sternum

<table>
<tr><td>Stomach</td><td>The stomach is a 'j'-shaped organ.
Two openings in stomach: (1) Esophageal (2) Duodenal
Four regions in stomach
1. Cardia
2. Fundus - Collects digestive gases,
3. Body - the body secretes pepsinogen and hydrochloric acid
4. Pylorus - Mucus, gastrin and pepsinogen secretion
The stomach has muscles which contracts and relax during digestion
The stomach can hold up to 1.5 liters of material.
 
Functions
• DIGESTION – mainly occurs in the stomach and small intestine where proteins, fats and carbohydrates are chemically broken down into smaller molecules.
○ Mechanical digestion occurs, in the mouth cavity with the help of tongue and teeth and as well as by peristalsis in the esophagus and stomach
○ Chemical digestion uses enzymes from salivary gland, stomach, duodenum and the liver.</td></tr>
<tr><td>Small intestine</td><td>The small intestine is composed of the duodenum, jejunum and ileum.
It averages approximately 6m in length, extending from the end of the stomach to the first part of the large intestine.
The small intestine is compressed into numerous folds and occupies a large proportion of the abdominal cavity.
The duodenum is the initial C-shaped section of the small intestine.
Functions
• The chemical and mechanical digestion is carried out
• ABSORPTION – is a process by which smaller molecules are absorbed across the wall of the small intestine and subsequently enter the circulation (blood).
• Rhythmical contractions force products of digestion through the intestine (peristalsis).</td></tr>
<tr><td>Large Intestine</td><td>The large intestine extends around the small intestine like a frame.
It consists of the appendix, caecum, ascending, transverse, descending and sigmoid colon, and the rectum.
It has a length of approximately 1.5m and a width of 7.5 cm.
The rectum is the final 15 cm of the large intestine. It expands to hold fecal matter before it passes through the anorectial canal to the anus.
Functions
• The large intestine removes water from the remainder, passing semi-solid feces into the rectum to be expelled from the body through the anus.
• The large intestine plays a key role in absorbing excess water, salts and vitamins
• EXCRETION - undigested material and secreted waste products are excreted from the body via defecation (passing of stool/faeces).
• Defecation is the discharge of waste matter (feces/stool) from the body.
• Peristalsis moves feces (waste matter) through the large intestine to the rectum, where they stimulate the urge to defecate (to pass stool).
• The rectum shortens, pushing the feces into the anal canal, where sphincters allow them to be passed or retained. Chest, abdominal, and pelvic muscles are used to during the process of defecation.</td></tr>
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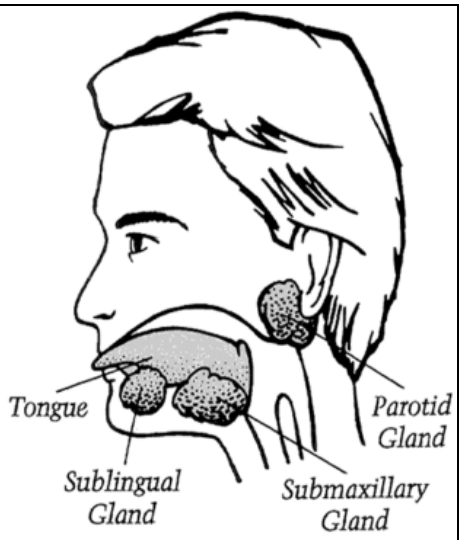
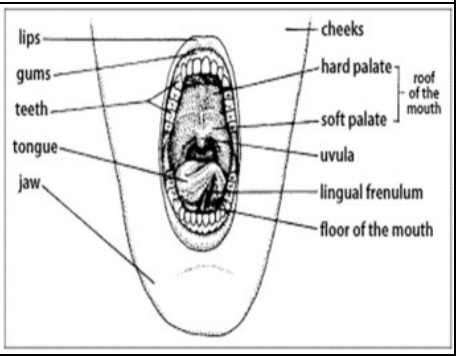
- **Salivary glands**
  - ✓ There are three pairs of salivary glands (parotid, submandibular, sublingual) that communicate with the oral cavity.
  - ✓ The glands secrete saliva in response to the taste, smell or even appearance of food.



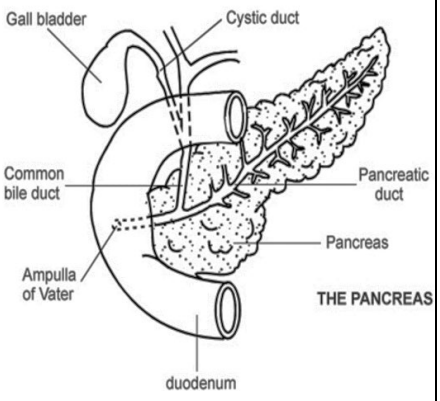
- **Teeth**
  - ✓ Humans have two sets of teeth: primary and permanent teeth (adult teeth). Primary teeth begin to emerge at around six months of age. Total number is 20.
  - ✓ Primary teeth fall out and are replaced by 32 permanent teeth (also called the adult teeth).
  - ✓ This happens over the time from when a child is from about 6 to 14 years old.
  - ✓ Teeth break down ingested food particles (mastication) with the saliva and the tongue.



- **Tongue**
  - ✓ The tongue is a strong and flexible muscular organ in the mouth which manipulates the food bolus to come in contact with the teeth.
  - ✓ The movement of the tongue helps to move food around the mouth so that a person can chew and swallow.
  - ✓ The tongue is also the sensing organ of the mouth for touch, temperature and taste.
- **Liver and gall bladder (**See more detailed in "Hepatobiliary System")
- **Pancreas**
  - ✓ The pancreas consists mainly of exocrine glands that secrete enzymes to aid in the digestion of food in the small intestine and endocrine glands that secrete hormones to regulate blood glucose level.
  - ✓ The pancreas has four sections: Head, Neck, Body, Tail

  Function

  The main enzymes produced by pancreas for fats, proteins and carbohydrates digestion are
    - Lipases
    - Peptidases
    - Amylases
    - Hormones secreted from endocrine glands of pancreas are
      - Insulin and
      - Glucagon



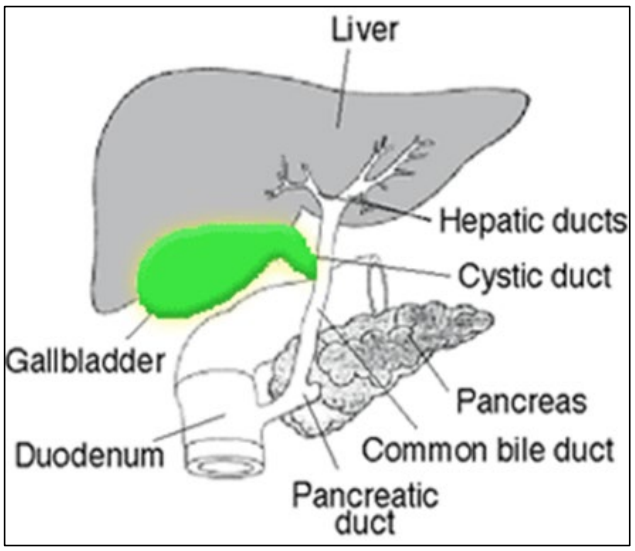
HEPATOBILIARY SYSTEM

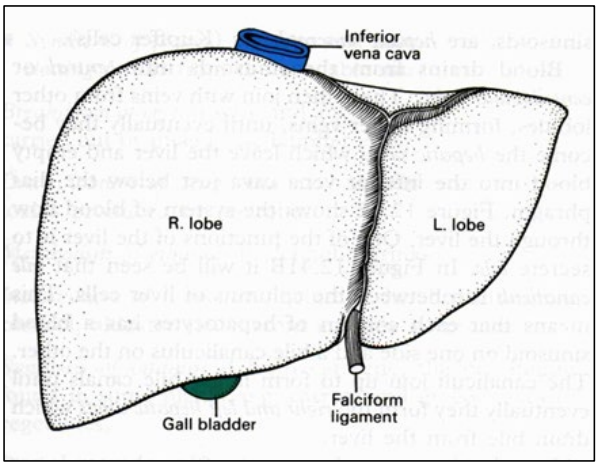
Anatomy of Gall bladder and Liver

The liver is the largest gland in the body. It is situated in the upper part of the abdominal cavity occupying the right hypochondriac, epigastric and left hypochondriac regions.

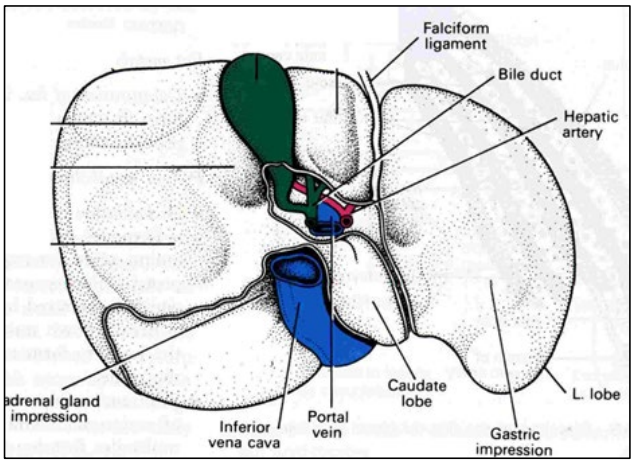
It has 4 lobes: right (the largest), left, caudate and quadrate lobes. It is surrounded by a strong capsule and divided two main lobes namely the right and left, lobes.

- The gallbladder is a hollow, flask (pear) shaped organ that sits in a depression on the inner surface of the liver's right lobe.





Liver: Anterior View



Liver: Posterior View (turned up)

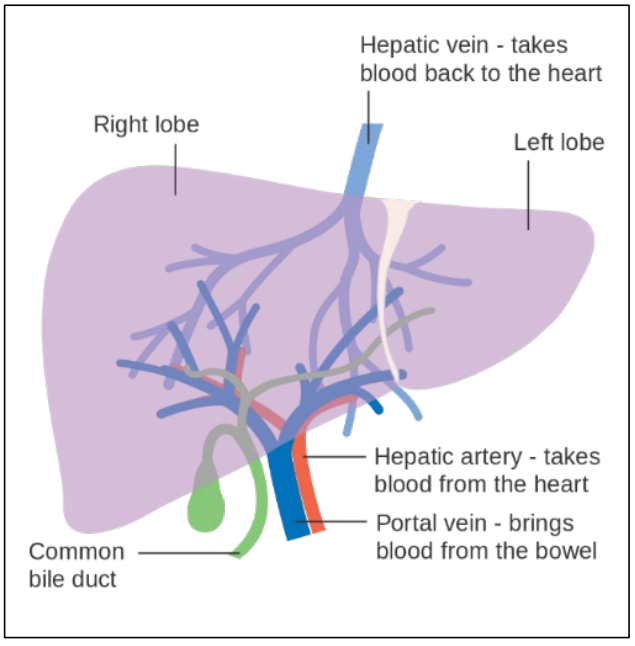
Portal Fissure (Porta Hepatis)

This is the part of the liver situated on its posterior surface where the following structures enter and leave: -

- Hepatic artery: enters, carrying arterial (oxygenated) blood.
- Portal vein: enters, carrying blood (deoxygenated, rich in nutrients) from the stomach, spleen, pancreas and small & large intestines.
- Nerve fibers: sympathetic & parasympathetic.
- Right & left hepatic ducts: leave, carrying bile from the liver to the gall bladder.
- Lymph vessels: leave, draining some lymph to abdominal & thoracic nodes.

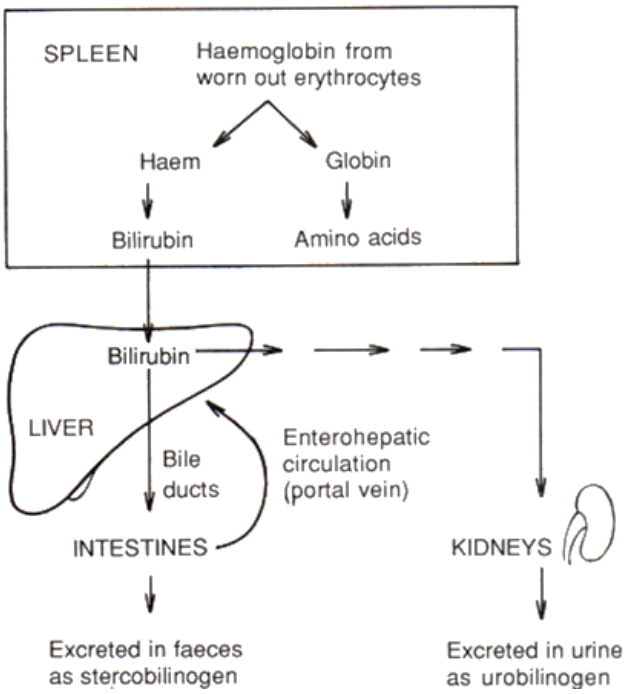
Blood Supply of Liver

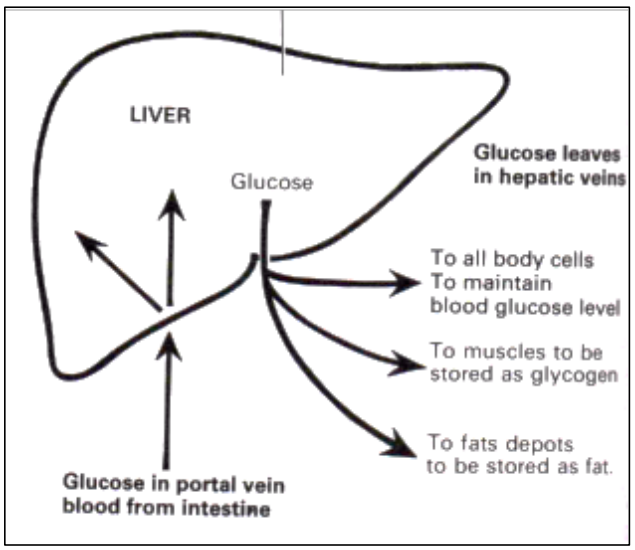
- Hepatic artery takes blood to the liver.
- Portal vein takes blood to the liver.
- Hepatic veins take blood away from the liver and enter inferior vena cava.



Functions of the liver

1. Synthesis of plasma proteins
2. Synthesis of blood clotting factors
- (prothrombin, fibrinogen, factors II, V, VII, IX and X).
3. Synthesis of vitamin A (from carotene)
4. Detoxification of drugs
5. Inactivation & excretion of toxic substances (such as alcohol, toxins produced by microbes).
6. Inactivation of hormones
- insulin
- glucagon
- cortisol
- aldosterone
- thyroid
- Sex hormones.
7. Production of heat
8. Secretion of bile
- bile salts
- bile pigments (bilirubin from RBC degeneration)
- Cholesterol.
9. Storage of fat-soluble vitamins (A, D, E, K)
10. Storage of some water-soluble vitamins
- riboflavin
- niacin
- pyridoxine
- folic acid
- vitamin B_{12}
11. Storage of minerals (iron & copper).
12. Metabolism of ethanol (in alcohol drinks)
13. Carbohydrate metabolism
- conversion of glucose → glycogen
- Conversion of liver glycogen → glucose. (Storage of extra glucose as glycogen; and breakdown of glycogen into glucose when required)

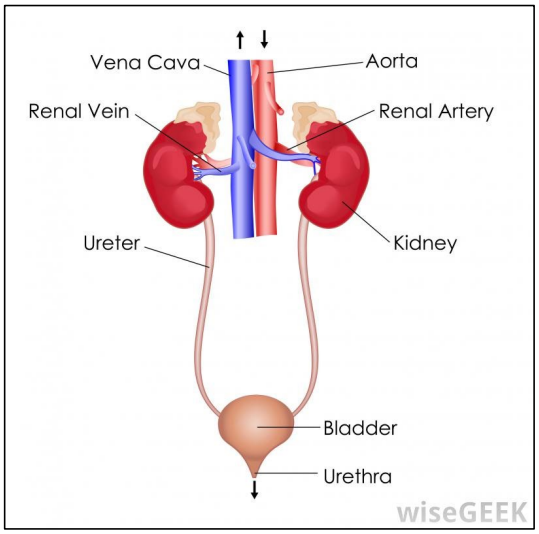




14. Fat metabolism
- Converts stored fats to a form in which it can be used by the tissues to provide energy.
15. Protein Metabolism
- Digestion breaks down the dietary protein to its constituent amino acids. These amino acids are transported to the liver. In the liver, some amino acids not required for building and repairing body tissues are broken down and converted to ammonia (toxic to the body). Ammonia is in turn converted to urea and excreted by the kidneys (in the urine).

URINARY SYSTEM

The kidneys are essentially regulatory organs, which maintain the volume and composition of body fluid by filtration of the blood and selective re-absorption or secretion of filtered solutes.



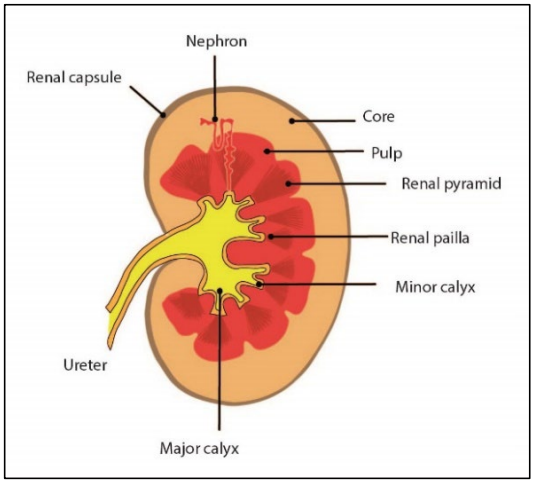
Anatomy

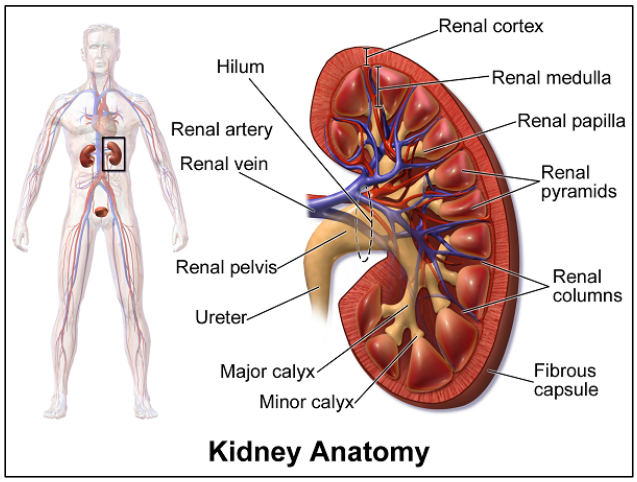
The urinary system consists of

- 2 kidneys
- 2 ureters
- Urinary bladder
- Urethra.

The Kidneys

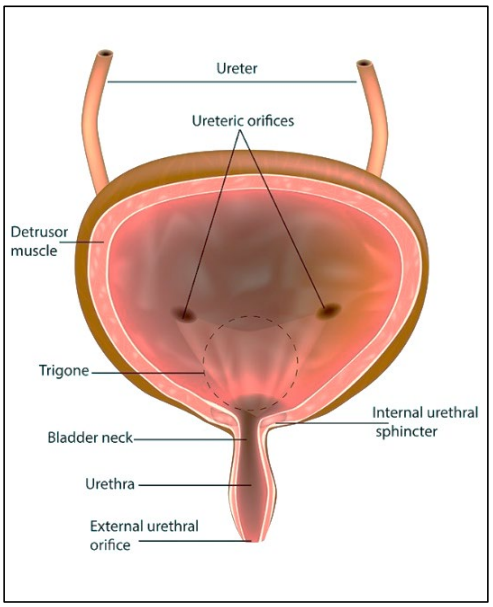
- There are two kidneys: the left and right kidneys. They are positioned high in the abdominal cavity, near the middle of the back.
- The right kidney is a little bit lower than the left one because of the liver.
- Each adult kidney has the shape of a big bean, the size is about 12 cm long.
- Each kidney is covered by the renal capsule. The capsule is a strong, transparent fibrous membrane that serves as a barrier against trauma and infection.
- Surrounding the renal capsule is a firm protective mass of fatty tissue called the adipose capsule.
- The outside layer, the renal fascia, is composed of dense irregular connective tissue. It is a supportive layer that anchors the kidney to the parietal peritoneum in front and to the abdominal wall in the back.
- Nephrons are the functional unit of the kidney. A nephron consists of a renal tubule and a small blood vessels.

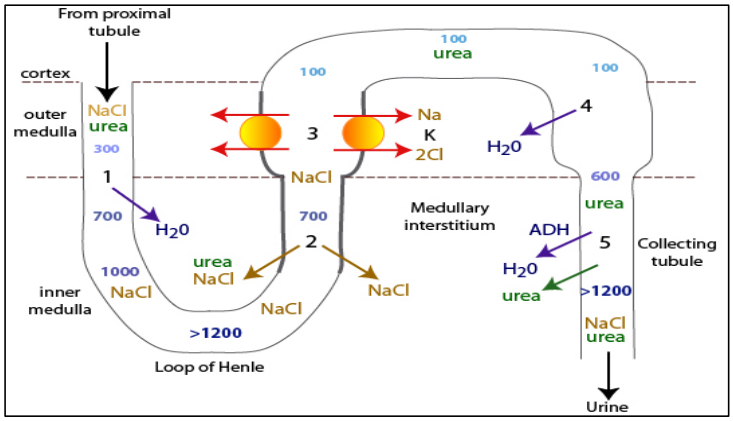




The ureters, bladder, and urethra

- The **ureters** are about 20 to 25 cm long. Muscles in the ureter walls constantly tighten and relax to force urine downward away from the kidneys.
- The **bladder** is a hollow muscular organ shaped like a balloon. It is located in the pelvis.
- Circular muscles called **sphincters** help keep urine from leaking. The sphincter muscles close tightly like a rubber band around the opening of the bladder into the urethra, the tube that allows urine to pass outside the body.
- The **urethra** is the tube that allows urine to pass outside the body.
- Male-approximately 18-20cm long and extends from the internal orifice of the urinary bladder to the external opening or meatus at the end of the penis.
- Female-About 4-6cm long and 6mm wide, the urethra is a tube, which runs from the bladder neck to open into an external hole, which is located at the top of the vaginal opening.



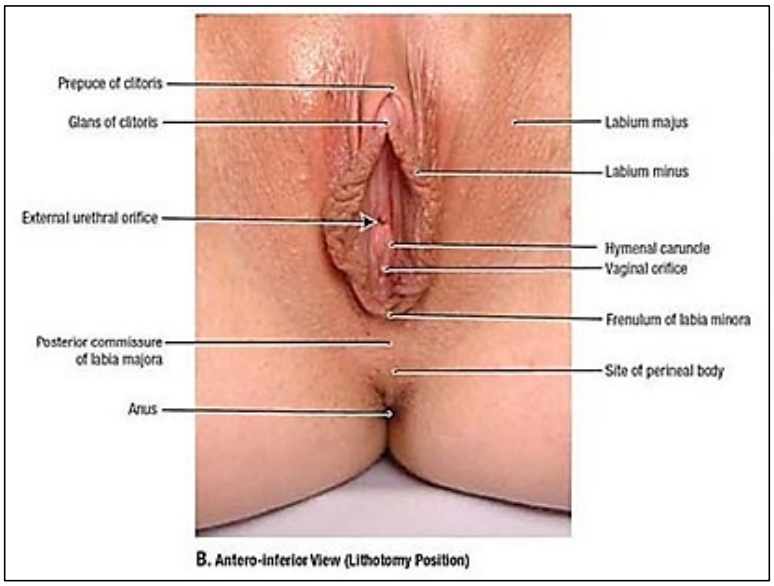


- The urinary system works with the lungs, skin, and intestines (all of which also excrete wastes) to keep the chemicals and water in the body balanced.
- The kidneys are filters for the blood. Water and other waste substances, forms the urine as it passes through the nephrons and down the renal tubules of the kidney.
- In the process of urine formation, the kidneys regulate:
    - the volume of the blood plasma
    - regulate the blood pressure.
    - the concentration of waste products in the blood.
    - the concentration of ions (Na+, K+, HCO3-…) in the blood plasma.
    - the pH of the blood plasma.
- These functions are vital to our survival. If our kidneys fail, our wastes will poison us. Humans produce about 1.5 liters of urine a day.
- From the kidneys, urine travels down through the ureters to the bladder. The bladder stores urine until the person is ready to empty it.
- **The Bladder**: Nerves in the bladder tell us when it is time to urinate (empty the bladder). When the bladder is full, the nerves from the bladder send a message to the brain that the bladder is full, and your urge to empty your bladder intensifies.
- **Urination**: When the person urinates, the brain signals the bladder muscles to tighten, squeezing urine out of the bladder. At the same time, the brain signals the sphincter muscles to relax. As these muscles relax, urine exits the bladder through the urethra. When all the signals occur in the correct order, normal urination occurs.

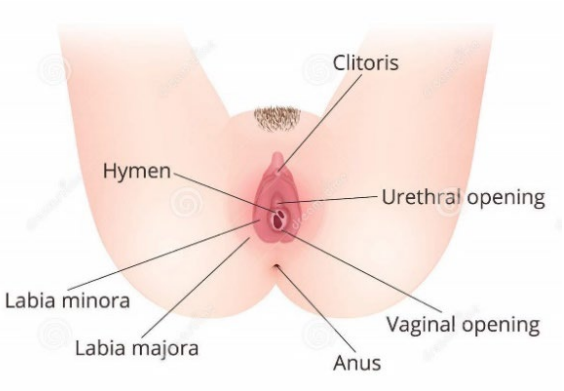
FEMALE REPRODUCTIVE SYSTEM

External Genitalia

- Mons pubis is a pad of fatty tissue overlying the symphysis pubic
- Labia majoras are folds of skin and fat which pass from mons to perineum
- Labia minoras are cutaneous fold enclosing urethral and vaginal orifices
- Clitoris is an equivalent to the penis and highly innervated
- Vaginal orifice is a midline aperture incompletely closed by the hymen
- Urethral orifice is a tiny vertical cleft like hole
- Vestibules is a space between the labia minorae.
- Bartholin's gland, that produce lubrication during sexual excitement, situated in the floor of vestibule
- Perineum is a diamond- shaped outlet of pelvis and the soft tissue which cover it.



B. Antero-inferior View (Lithotomy Position)

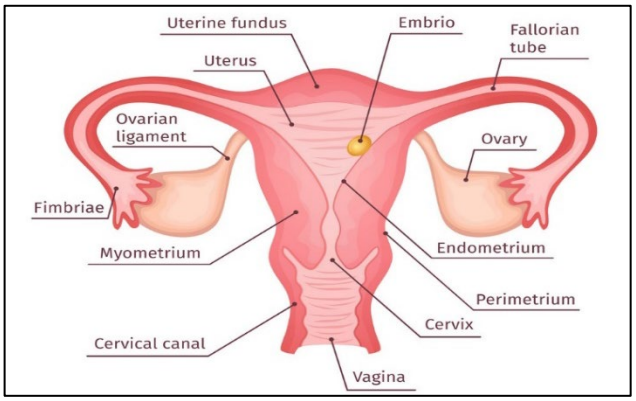


Internal Genitalia

Uterus

The uterus is a hollow, pear shaped organ located in the pelvis between the bladder and rectum. The uterus is capable of undergoing great changes in size and development during pregnancy. It is continuous with the fallopian tubes and the vagina. The uterus is divided into

- Body- upper part of uterus.
- Cervix- narrow lower part of uterus, which is continuous with the upper vagina.



The wall of the uterus is made of three layers

- Outside layer of serosa (perimetrium)
- Middle layer of muscle (myometrium)
- Inside layer of mucosa (endometrium)

The blood supply of the uterus is from the uterine and ovarian arteries. The uterine veins follow the arteries and form a network on each side of the cervix. The nerves to the uterus come from the utero vaginal network.

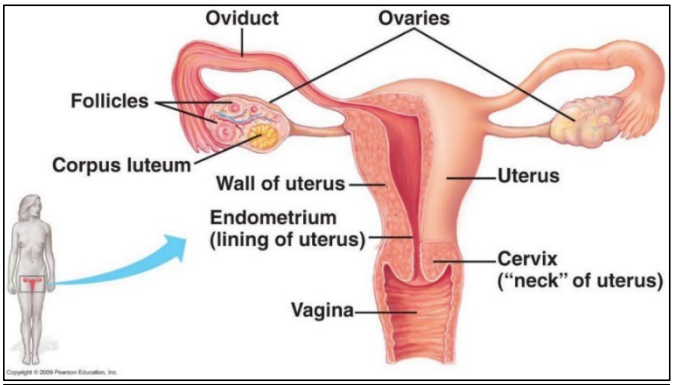
Cervix

- It is lower third of the uterus
- Its function is to provide an alkaline secretion for the sperm to penetrate
- Once pregnant it acts as a sphincter

Fallopian Tubes

These are fine tubes, leading from the ovaries to the uterus. They are important for transmitting eggs from the ovary to the uterus. This process is necessary for fertilization and initial development of the baby. The fallopian tubes are10-12 cm long and divided into four main areas:

- Infundibulum: This is the funnel shaped part of tube next to the ovary. There are finger like extensions (fimbriae), which extend towards the ovary. These aid passage of the egg to uterus.
- Ampulla: The segment where fertilization usually occurs.
- Isthmus: Narrow segment of fallopian tubes, next to uterus.
- Uterine segment: The part of the fallopian tube fixed into the uterine wall.



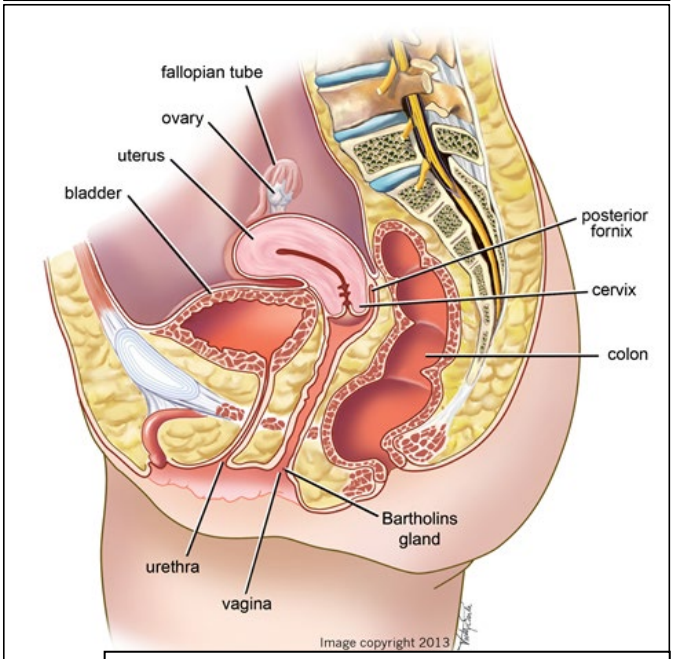


Fig: Lateral view of Female Reproductive Organ

Ovary

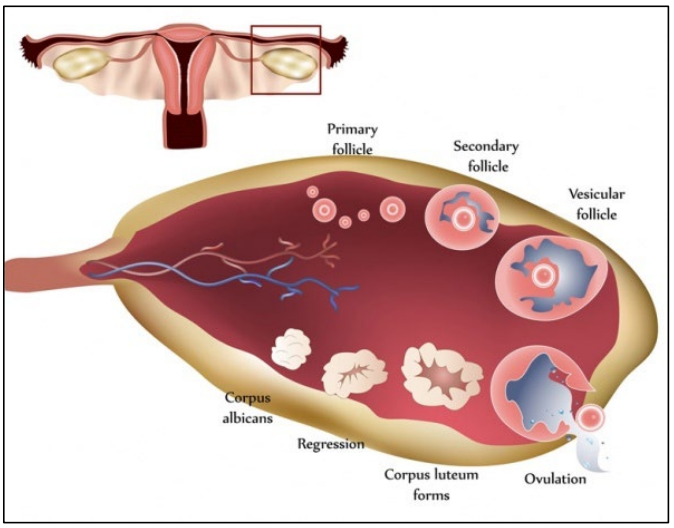
Normally females have two ovaries, which function mainly to produce eggs and secrete hormones (including estrogen and progesterone). These hormones released help regulate maturation of eggs and help in producing body-changes during puberty. The ovaries are attached to special ligaments (sheets of tough tissue), and to the uterus. As females develop within the womb, each ovary has a number of immature (young) eggs. Through puberty, the eggs mature and are released from the ovaries during ovulation. Blood supply of the ovary is from blood vessels called the ovarian arteries.

Vagina

The vagina is a muscular tube 6 -7.5cm long, which leads from the uterus to the outside of the body.
The vaginal wall consists of

- Inner tissue layer
- Intermediate muscle layer
- Outer tissue layer

The wetness and moisture of the vaginal surface is achieved by mucous from the cervix. The outer layer is made of elastic fibers, blood vessels, lymph vessels and nerves. The elastic fibers give the vaginal wall its strength and elasticity. The functions of the vagina are: copulation (admitting the penis during sexual intercourse), allowing menstrual blood to leave the body, and giving birth.



Physiology of the Female Reproductive System

The dominant process, which appears to control the physiology of female reproductive organ during reproductive life, is the cyclical growth and maturation of ovarian follicles.

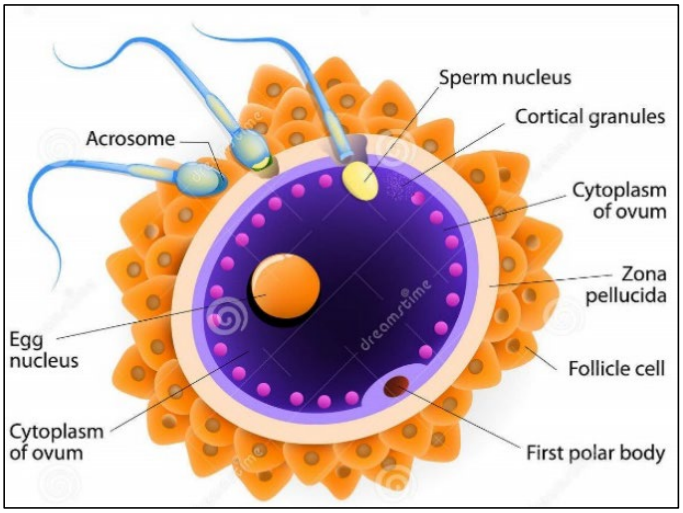
Ovulation

Puberty occurs in the female at about age ten to thirteen when her ovaries begin to produce **Ovarian Follicle**. It is made up of an immature ovum surrounded by layers of cells. Development of ovarian follicle occurs in response to stimulation from hormone produced from the brain. The follicle continues to grow to a size of more than 1 cm. During the childbearing years, every month, one ovarian follicle matures; it ruptures and releases its ovum. The process of the egg leaving the ovary is called **OVULATION**.

Fertilization

If a man has sexual intercourse with a woman at her time of ovulation it is possible for the sperm which have been released into the vagina to swim up the uterus and into the fallopian tubes. The joining of an egg and a sperm cell in the fallopian tube is called "**FERTILIZATION".** A fertilized egg continues to move down the fallopian tube to the uterus and attaches itself to the uterine wall.

The uterus supports the fertilized egg for approximately nine months as it grows and develops into a fetus. The developing fetus receives the nutrients through an organ called the placenta. The placenta is formed from the lining of the uterus and part of the developing egg.



Menstruation

When an egg has not been fertilized, the prepared uterus is not necessary. The inside covering of the uterus cannot be used 14 days after ovulation; it will be broken down and leave the uterus through the vagina. The woman bleeds. This is called **MENSTRUATION**. It takes 2 to 6 days for the uterus to get rid the entire inside covering. The menstruation always occurs 14 days after ovulation.

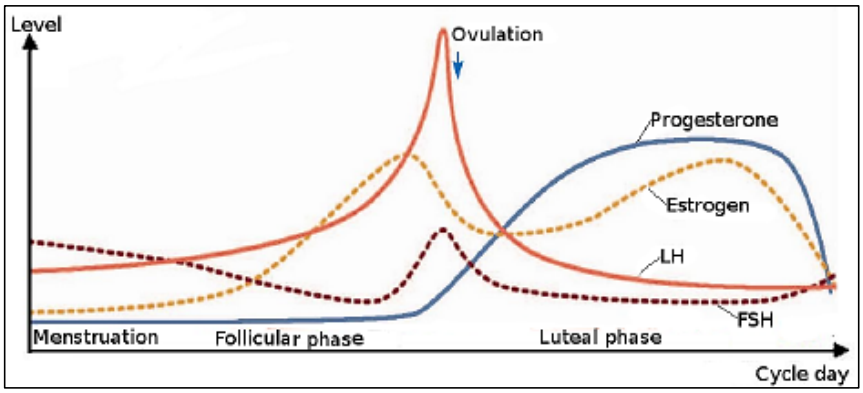
The ovulation (the time a ripe egg leaves the ovary) is always 14 days before the first day of menstruation (bleeding). The egg and the preparation of the uterus take about 14 days before ovulation. Therefore, the normal time between one menstruation and the next is 28 days. It can also be longer or shorter without being abnormal. By definition the first day of the menstrual cycle is the first day of menstruation. It's internationally decided that the first day of the menstruation is called the 1st day of the cycle.

Female Reproductive Hormones

There are variety of hormones that influence the structure and function of female reproductive system. They are:

- When a girl reaches puberty, the ovaries are stimulated by hormone from brain ***(Follicular Stimulating Hormone FSH)***, which promotes the maturation of ovarian follicles.
- While maturing, the follicle lining produces hormone ***Estrogen.***
- After ovulation the lining cells of ovarian follicle left inside the ovary develop into yellow mass of cell and produce hormone ***Progesterone*** and it continues to produce ***Estrogen***.
- If the ovum is fertilized it embeds itself in the wall of uterus where it grows and produces hormone ***(Human Chorionic Gonadotropin HCG)***

A number of physical and psychological changes take place in the body of the women because of these hormones. The estrogen and progesterone are also known as *ovarian hormones* as they are produced in the ovaries.



Effects of Ovarian Hormones (estrogen and progesterone)

Estrogen purpose is to develop the child into the adult female and prepare for reproduction. Progesterone prepares the fertilized ovum for the implantation and continuation of pregnancy.

Genital tract

Estrogen stimulates growth and vascular station of the endometrium and progesterone increases endometrial gland secretion.

Estrogen stimulates the secretion of the cervix to produce a favorable medium, while progesterone dries it up. Estrogen effects to proliferate of vagina epithelium while progesterone causes the mucus secretion and relaxation of vagina epithelium.

Breast

Estrogen stimulates growth of duct system and pigmentation. Progesterone stimulates growth of breast glands.

Cardiovascular system

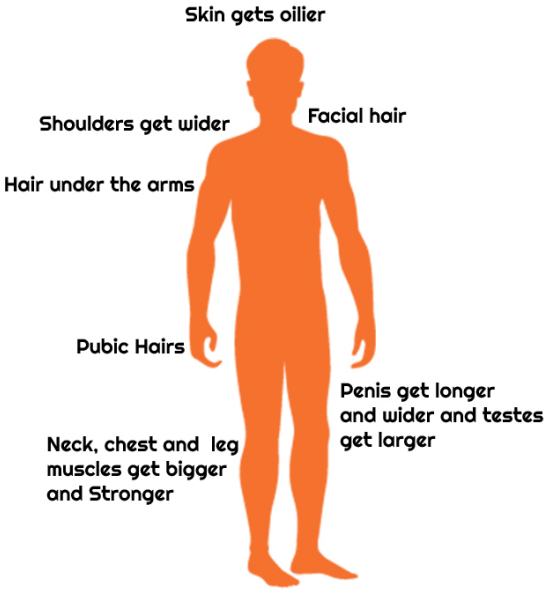
Estrogen relaxes the smooth muscles of the vessels and causes vasodilatation, tending to improve circulation and prevent hypertension. Estrogen and to a lesser extent progesterone cause water and salt retention.

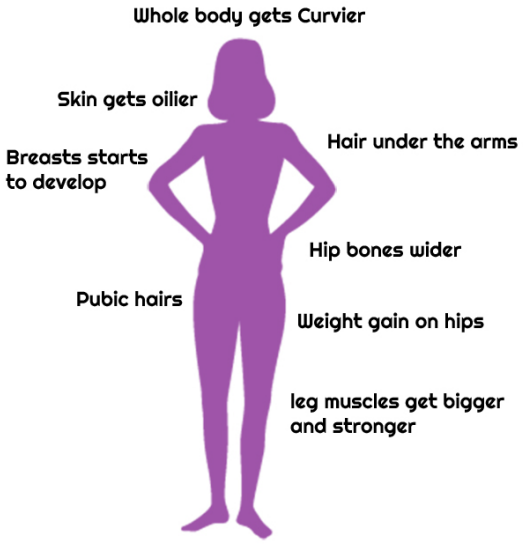
Psychological Characteristics

Fluctuation of the menstrual cycle does some extent affect the individual's attitude and mood. During estrogen phase the women is more active, cheerful and energetic. Progesterone leads to reduced physical activity, quieting mood and some depression.

Puberty

Puberty is the combination of physical and emotional changes that occur when a girl or boy becomes a young woman or man. Puberty usually starts sometime between age 8 and 13 in girls and 10 and 15 in boys. Puberty takes place at the point when the gonads (sex organs) start producing sex hormones. Sex hormones stimulate growth and development of reproductive organs as well as changes throughout the body.





Changes in boys

- Development of the sex organs (lengthening of the penis and the enlargement of the testes)
- Hair will begin to grow in pubic area, on the face and axillary.
- Sweating increases and there is a change in body odor.
- Skin will begin to become oily than usual. This can cause acne and pimples.
- Broadening of the shoulders, muscles become strong.
- The larynx lengthens and the voice becomes deeper.

Changes in girls

- Breasts begin to grow in size.
- Hairs begin to grow in pubic area and axillary.
- Sweating increases and there is a change in body odor.
- Skin will begin to become oily; this can cause acne and pimples.
- The hips and thighs will widen, and the pelvis expands. The body will begin to have more curves.
- Menstruation begins.

Menopause

It occurs typically between her late 40s and early 50s (42-58). Menopause is the transition period in a woman's life when

- Her ovaries stop producing eggs
- Her body produces less estrogen and progesterone
- Menstruation becomes less frequent, and
- Finally, stopping altogether reaching the end of the fertile phase of a woman's life.

The hormonal changes cause a variety of transient menopausal signs and symptoms in many women.

Irregular menses Breast tenderness Vasomotor instability (hot flashes and night sweats) Atrophy of genitourinary tissue	Vaginal dryness Increased stress, insomnia, forgetfulness, Mood changes, decrease libido Osteoporosis Heart disease, palpitation

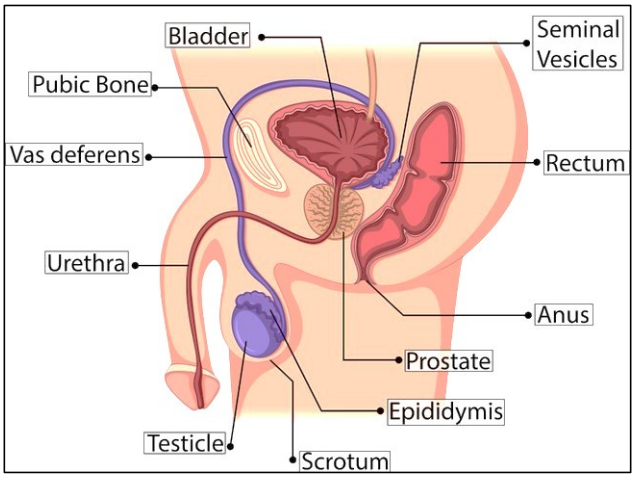
MALE REPRODUCTIVE SYSTEM

Testes

The testis is a firm mobile organ lying within the scrotum, with the left testis lying slightly lower than the right.

Function

- Production of sperm
- Production of testosterone, which is responsible for the development of secondary sexual characteristics in the male



Epididymis

The epididymis is a firm structure that consists of three parts, the expanded head, the body and the tail. The epididymis is a coiled tube and approximately 6-7m long. At the tail of the epididymis a tube called the vas deferens emerges.

Vas Deferens

The vas deferens is a 45 cm long muscular tube that transports sperm to the ejaculatory ducts.

Ejaculatory Ducts

The two ejaculatory ducts are formed as a result of the union of the vas deferens with the ducts arising from the seminal vesicles (accessory glands that secrete fluid) on either side. They are approximately 2cm long and pierce the prostate gland emptying into the part of the urethra that runs through the prostate.

Urethra

The male urethra is approximately 18-20cm long and extends from the internal orifice of the urinary bladder to the external opening or meatus at the end of the penis.

Penis

There are 2 main parts of the penis

- Root: There are three main parts of the root of the penis; the midline bulb and the left and right crura either side of the bulb.
- Body: Three cylindrical masses of erectile tissue constitute the body of the penis. Two structures called the corpus cavernosa on either side or the corpus spongiosum in the midline. At the end of the corpus spongiosum is the head of the penis; this is where the urethra opens.

Function: (1) Erection (2) Ejaculation

Prostate Gland

Surrounding the prostatic part of the urethra is the fibro muscular prostate gland. The gland is usually about 3 cm long and is surrounded by a capsule. The prostate is divided into five lobes.

Accessory Glands

Seminal vesicles

Two seminal vesicles are, situated symmetrically at either side of the bladder. They are a coil shaped structure and are approximately 5 cm long. Each seminal vesicle narrows inferiorly to join the vas deferens forming the ejaculatory duct.

Function: Produce a secretion that contains substances to help provide nourishment to the spermatozoa, and the contraction of the walls of this gland during ejaculation expels this fluid into the ejaculatory ducts forcing the spermatozoa out of the urethra.

Bulbourethral Glands

These are two small rounds and yellow glands 1cm in diameter.

Function: Produce a secretion that helps lubricate the head of the penis during erection and ejaculation.

MUSCULOSKELETAL SYSTEM

Anatomy of Musculoskeletal System

The musculoskeletal System consists of skeletal system (bone and joint) and muscle system. These two systems serve many important functions; it provides the shape and form for our bodies in addition to supporting, protecting, allowing bodily movement, producing blood for the body, and storing minerals.

There are 5 basic tissues comprising the musculoskeletal system:

- Bone
- Ligament (attaching bone to bone)
- Cartilage (protective gel- lie substance lining the joints and intervertebral discs),
- Skeletal muscles and
- Tendons (attaching muscle to bone)

There are three types of muscles

Smooth muscles (involuntary) are found in the wall of digestive tract, blood vessels, the respiratory tract, the urinary tract etc. E.g., the wavelike, regular contractions of smooth muscles of the GIT (peristalsis) help to mix food and move it along the length of the tract

Cardiac muscles are found in the heart which contracts involuntary

Skeletal muscles (voluntary) are responsible for the movements of body parts and for locomotion. They are attached to the bones by tendons. They produce movement by bending the skeleton at movable joints.

Functions of Bones

- Its 206 bones form a rigid framework to which the softer tissues and organs of the body are attached
- Vital organs are protected by the skeletal system
- Bodily movement is carried out by the interaction of the muscular and skeletal systems
- Blood cells are produced by the marrow located in some bones
- Bones serve as a storage area for minerals such as calcium and phosphorus.

Divisions of the skeleton

- The human skeleton is divided into two distinct parts:
- The axial skeleton consists of bones that form the axis of the body and support and protect the organs of the head, neck, and trunk.
  - The Skull
  - The Sternum
  - The Ribs
  - The Vertebral Column
- The appendicular skeleton is composed of bones that anchor the appendages to the axial skeleton.
  - The Upper Extremities
  - The Lower Extremities
  - The Shoulder Girdle
  - The Pelvic Girdle

Types of Bone

- The bones of the body fall into four general categories
  - Long bones- humerus, tibia, femur, ulna, metacarpals
  - Short bones- found in the wrists and ankles
  - Flat bones- ribs, cranial bones, bones of shoulder girdle
  - Irregular bones- the bones of the vertebrae

Joints

A joint, or articulation, is the place where two bones come together. Joints are composed of:

- Cartilage
- Ligaments
- Tendons
- At least 2 bones
- Gliding (in the carpals in the wrist and the tarsal in the ankle)

There are three types of joints classified by the amount of movement they allow.

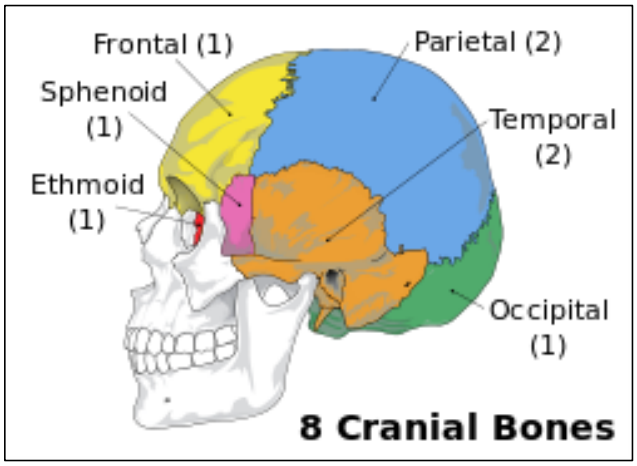
- Immovable joints –the suture in the skull between skull bones.
- Slightly movable joints -The ribs that connect to the sternum
- Freely movable joints there are six types of freely movable joints.
  - Ball-and-Socket (shoulder and hip)
  - Condyloid (metacarpals, metatarsals, and phalanges)
  - Saddle (in the thumb)
  - Pivot (joint between the axis and atlas in the neck)
  - Hinge (in the elbow and knee joints)

The Skull

Cranial Bones

The cranial bones make up the protective frame of bone around the brain. The cranial bones are:

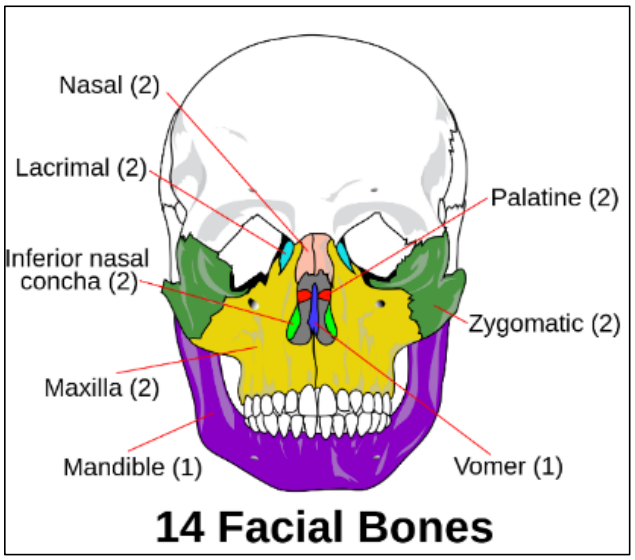
- Frontal,
- Parietal
- Temporal
- Occipital
- Sphenoid
- Ethmoid



Facial Bones

The facial bones make up the upper and lower jaw and other facial structures. The facial bones are:

- Mandible
- temporomandibular
- Maxilla
- Palatine
- zygomatic
- Nasal
- lacrimal
- vomer



The Ribs

The ribs are thin, flat, curved bones that form a protective cage around the organs in the upper body. They are comprised of 24 bones arranged in 12 pairs.

Sternum

The sternum or beast bone is a long flat bone located in the central part of the chest. It connects to the ribs via cartilage and forms the front of the rib cage, thus helping to protect the heart, lungs and major blood vessels from injury.

The Vertebral Column

The vertebral column (also called the backbone, spine, or spinal column) consists of a series of 33 irregularly shaped bones, called vertebrae. These 33 bones are divided into five categories depending on where they are located in the backbone. In between the vertebrae are intervertebral discs made of fibrous cartilage that act as shock absorbers and allow the back to move.

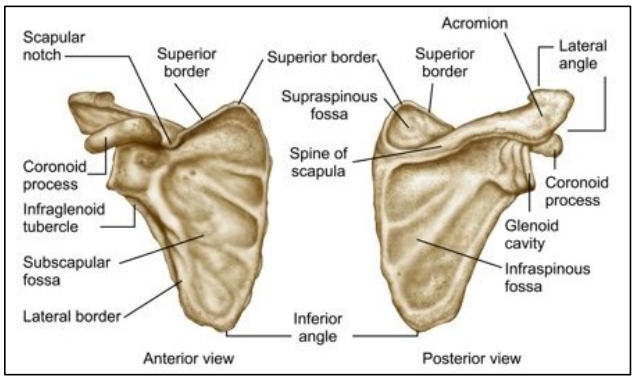
- Cervical vertebrae
- Thoracic vertebrae
- Lumbar vertebrae
- Sacrum
- Coccyx

Upper Extremities

The upper extremity consists of three parts: the arm, the forearm, and the hand.

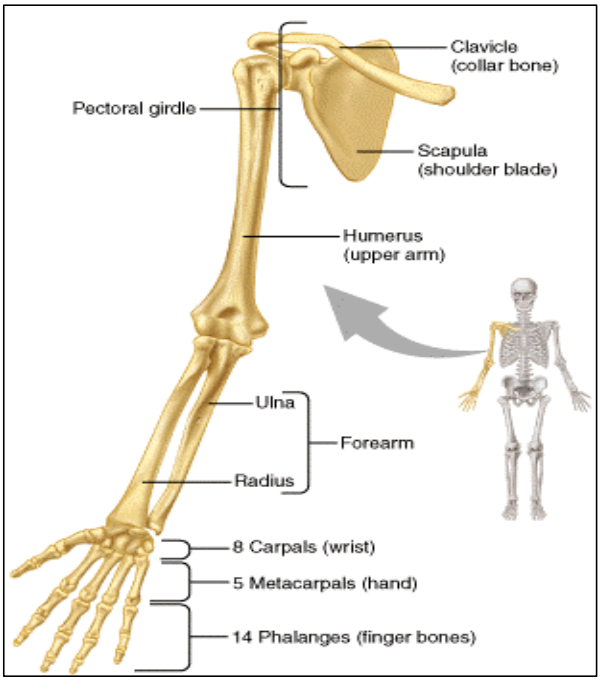
Shoulder girdle

The clavicle, commonly called the collarbone, is a slender S-shaped bone that connects to the sternum and also connected to the scapula. Scapula is a large, triangular, flat bone on the backside of the rib cage commonly.



Arm

The arm is region between the shoulder and elbow. It consists of a single long bone called the humerus. The humerus is the longest bone in the upper extremity.



Forearm

The forearm is the region between the elbow and the wrist. It is formed by the radius on the lateral side and the ulna on the medial side. The ulna is longer than the radius and connected more firmly to the humerus.

Hand

The hand consists of three parts (the wrist, palm, and five fingers) and 27 bones.

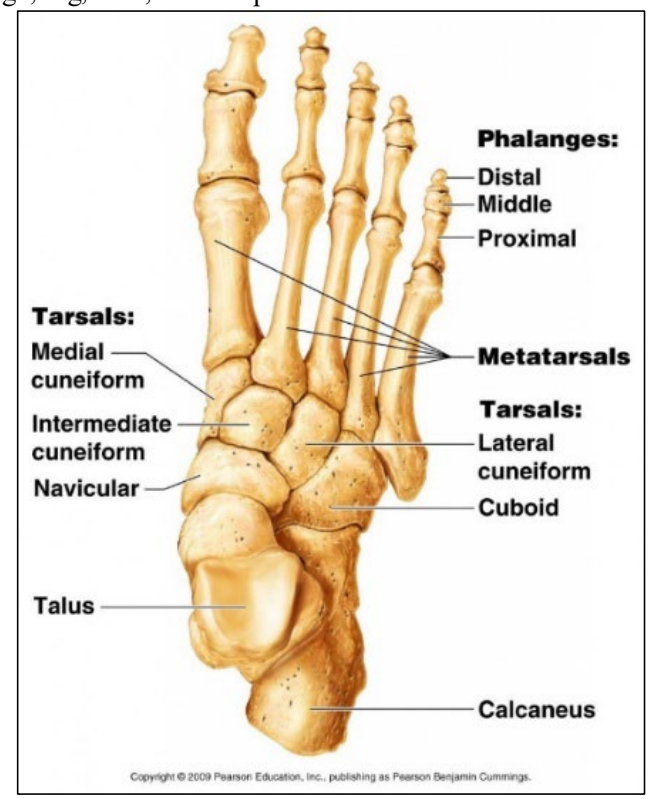
- The wrist consists of 8 small carpal bones that are tightly bounded by ligaments. These bones are arranged in two rows of four bones each.
- The palm consists of five metacarpal bones.
- The fingers are made up of 14 bones called phalanges.

Lower Extremities

The lower extremity is composed of the bones of the thigh, leg, foot, and the patella.

Thigh

The thigh is the region between the hip and the knee and is composed of a single bone called the femur. The femur is the longest, largest, and strongest bone in the body.



Patella

The patella or kneecap is a large, triangular sesamoid bone between the femur and the tibia.

Leg

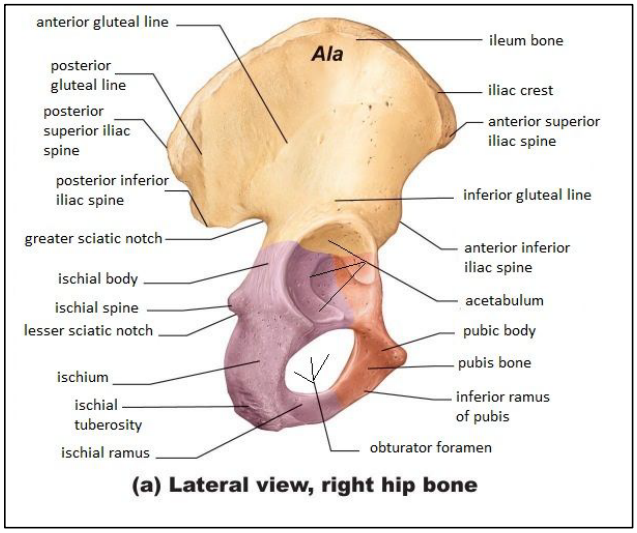
The leg is the region from the knee to the ankle. It is formed by the fibula on side away from the body (lateral side) and the tibia, also called the shin bone, on the side nearest the body (medial side).

Foot

Foot contains

- Tarsal bones
- calcaneus
- Talus
- Navicular bone
- Cuneiform bones
- Cuboids bone
- Metatarsal
- Phalanges

The Pelvic Girdle, also called the hip girdle, is composed to two coxal (hip) bones. In the back, these two bones meet on either side of the sacrum. In the front, they are connected by a muscle called the pubic symphysis. Each hip bone consists of 3 portions. Ileum or the upper flattened part

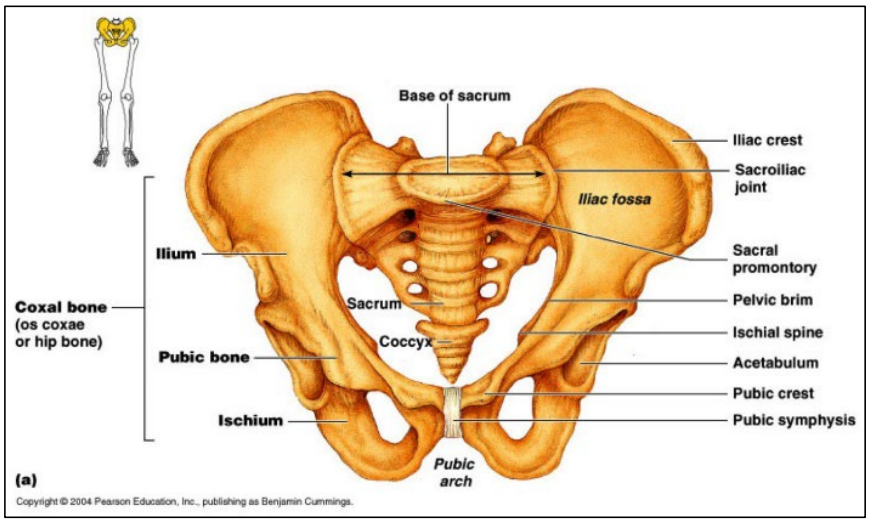


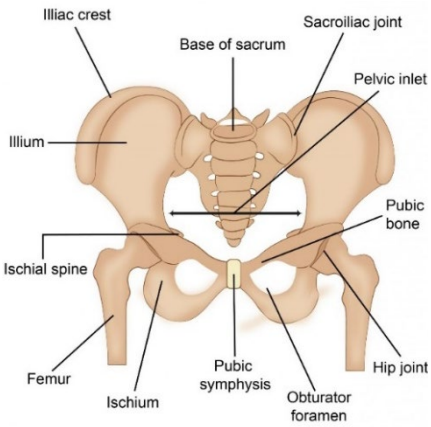
Pubis or front part. This bone is connected with the other pubis of the hip bone at a joint, the" symphysis pubic". Ischium or the lower and posterior part and bear the weight of the body when we sit.

Sacrum is made up of five indistinct vertebrae fused to form lower, wedge-shaped bone. On each side it articulates with ileum or the upper flattened part of the hipbones

The cavity of pelvis is divided into:

- Inlet or brim
- Cavity
- Outlet



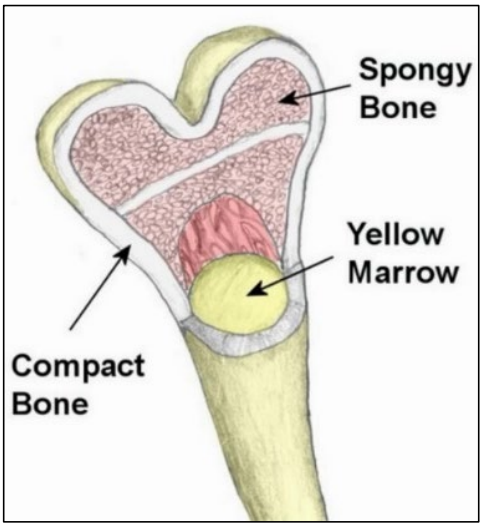


Inlet or brim is bounded:	Cavity is bounded:	Outlet is bounded:
• In front by upper border of pubic bones • On the sides by ileum or upper part of hip bones • At the back by upper part of sacrum	• Above by inlet or brim • Below by outlet • In front by posterior (back) surface pubic bones • At the back by inner protruding surface of scrum • On the sides by the inner surface of hip bones (ischium) • There are 2 bony spines (ischial spines), projecting from each hip bone, is an important obstetrical land mark, being the narrowest part of pelvis cavity	• In front by lower border of pubic bones which form an arch • On the sides by bony portion of hip bones on which we sit • Back by the lowest triangular shaped vertebra

Bone Composition

Bones are composed of tissue that may take one of two forms.

(1) Compact, or dense bone
(2) Spongy, or cancellous, bone.



Most bones contain both types. Compact bone is dense, hard, and forms the protective exterior portion of all bones. Spongy bone is inside the compact bone and is very porous (full of tiny holes). Spongy bone occurs in most bones.

The bone tissue is composed of several types of bone cells embedded in a web of inorganic salts (mostly calcium and phosphorus) to give the bone strength, and collagenous fibbers and ground substance to give the bone flexibility.

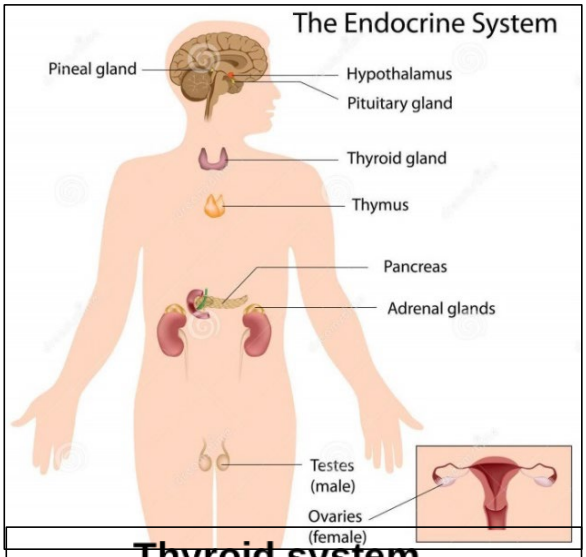
Bone Cells

There are five main types of bone cells in bone tissue.

(1) Osteogenic cells respond to traumas
(2) Osteoblasts (bone-forming cells) synthesize and secrete un-mineralized ground substance
(3) Osteocytes maintain healthy bone tissue by secreting enzymes and controlling the bone mineral content.
(4) Osteoclasts are large cells that break down bone tissue. They are very important to bone growth, healing, and remodeling
(5) Bone-lining cells regulate the movement of calcium and phosphate into and out of the bone.

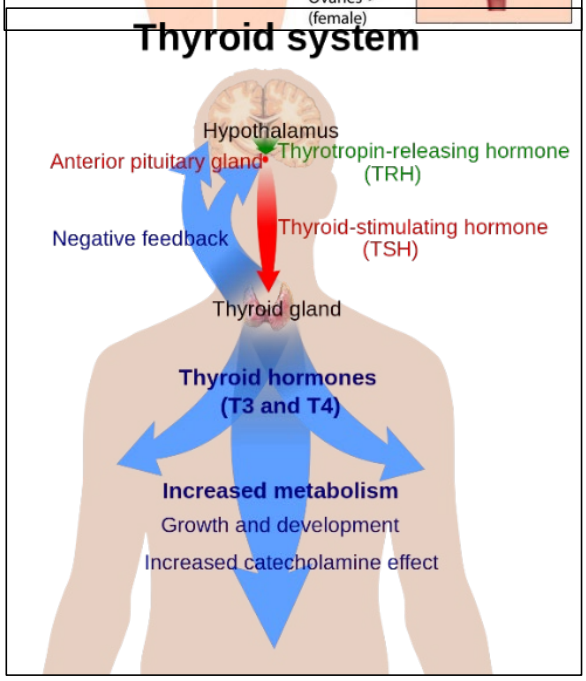
ENDOCRINE SYSTEM

The main function of the endocrine system is to regulate body metabolism, body growth and reproduction. The endocrine system works with the nervous system to perform all the activities.



Exocrine glands- are glands (organ) with duct that secrete/produce and release one or more substances to be use in the body e.g., hormones, enzymes etc.
Endocrine glands–are glands (organ) without duct that secrete/produce chemicals which are released directly into the bloodstream. They have no tubes/duct, are also called **ductless glands**.
Hormones - are chemicals (proteins) which are produced by endocrine organs, they are released into the blood or interstitial tissue and transported to their target organs.
The endocrine system consist of 5 main glands

(1) The pituitary gland
(2) The thyroid glands
(3) The pancreas
(4) The sex organs (Gonads)
(5) The adrenal glands



The Pituitary Gland

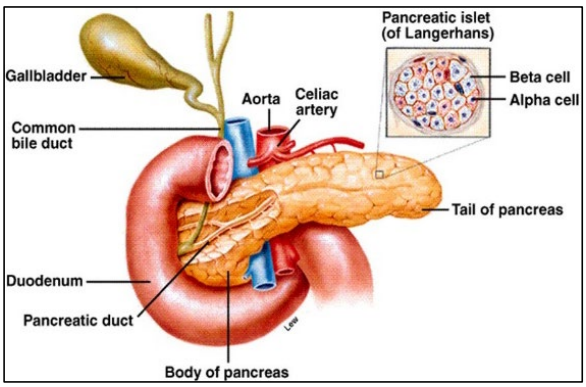
The **pituitary gland** is located on the lower part of the brain. Gland is regulated by the part of the brain called the hypothalamus and secretes/produces hormones which regulate/control the normal function of other endocrine glands
Examples:
TSH = thyroid stimulating hormone,
GSH = growth stimulating hormone
The pituitary gland also secretes/produces **Anti Diuretic Hormone (ADH)** which helps to retain water by the kidneys and **Oxytocin** stimulates contractions of uterus during labor and mild production and release.

The Thyroid

The thyroid gland is located just below the larynx, in front of the trachea. The thyroid gland secrete/produces a hormone called thyroxin (**T4**) and triiodothyronine (**T3**) which helps to regulate metabolic rate and is needed for proper growth and development. The production of T3 and T4 from the thyroid is regulated by the TSH. **Iodine** is essential for the synthesis of thyroxin. Iodine rich foods include sea food, iodine salt.

The Pancreas

The pancreas is both an **endocrine** and an **exocrine** gland. The endocrine portion of the pancreas secretes **insulin** which regulates blood glucose level, and other hormones (glucagon). The exocrine portion of the pancreas secretes digestive enzymes that helps the digestion and absorption of nutrients in the digestive system.



Insulin

- **Purpose:** Regulate blood glucose (sugar) in the normal range
- **Action:** Forces many cells of the body to absorb and use glucose thereby decreasing blood sugar levels.
- **Secreted in response to:** High blood glucose
- **Secretion inhibited by:** Low blood glucose
- **Disease due to deficient action:** Diabetes

Glucagon

- **Purpose:** Assist insulin in regulating blood glucose (sugar) in the normal range (actions are opposite of insulin)
- **Action:** Forces many cells of the body to release (or produce) glucose (increasing blood sugar)
- **Secreted in response to:** Low blood glucose
- **Secretion inhibited by:** High blood glucose

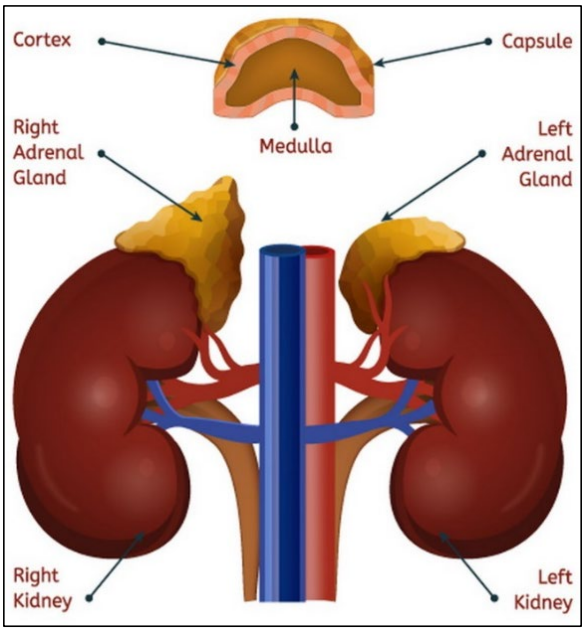
The Sex Organs (Gonads)

The testes are the primary sex organs of the male reproductive system located in the scrotum. The testes produce sperms cells and testosterone hormone. Testosterone regulates sperm formation and the growth of muscles and bones

The ovaries are the primary sex organs of the female reproductive system located in the pelvic cavity. They produce female gametes and female sex hormones: estrogens and progestogens.

The Adrenal Glands

The **adrenal glands** are paired organs (right and left) that are located at the superior borders of the kidneys. Each gland is composed of **Adrenal cortex** (outside) and **Adrenal medulla** (inside).



The adrenal cortex

The adrenal cortex secretes **corticosteroid hormones (corticoids)** It exist 3 categories:

(1) **Mineralocorticoids** – Aldosterone are hormones which regulates salt retention in the body
(2) **Glucocorticoids** - Cortisol (hydro-cortisone) –are hormones, which regulate the metabolism of glucose (see notes of the immune system)
(3) **Androgens** - Sex steroids

The adrenal medulla

- The adrenal medulla is secretes **epinephrine** and **norepinephrine**.
- The effects of these hormones are similar to the effects caused by stimulation of the sympathetic nervous system (see note of the nervous system)

Others Endocrine Glands

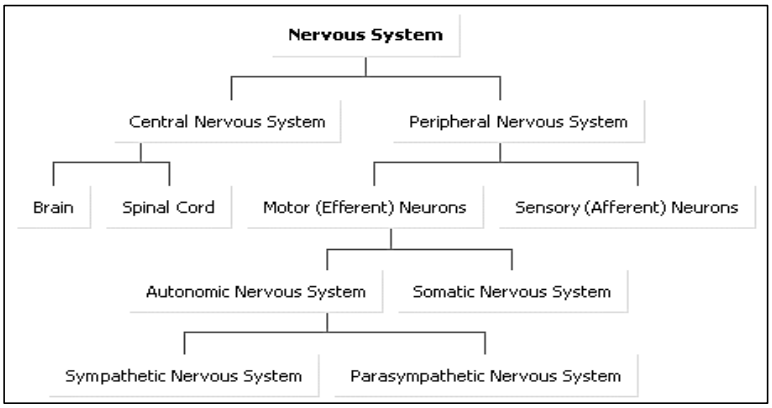
Pineal gland, parathyroid glands, thymus, stomach and small intestine and the placenta.

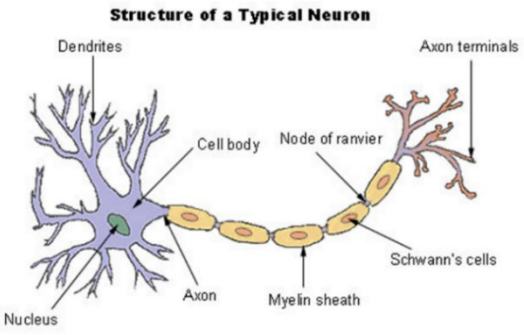
NERVOUS SYSTEM

Neuron

Neurons are nerve cells that can communicate with other cells by the rapid transmission of either electrical or chemical signals (neurotransmitters) via synapses (membrane to membrane junction). The nervous system is defined by the presence of neurons.

The nervous system controls all functions of the body. It is a very complex system, which consists of:





Central Nervous System (CNS)

The central nervous system consists of *the brain* and *the spinal cord*. They serve as a control center for all body functions. These organs integrate in-coming information and determine appropriate responses through the peripheral nervous system. CNS is very well protected with:

- Skull and vertebrae
- Meninges (covering layers of brain and spinal cord)
- Cerebral Spinal Fluid (CSF - involved in nutrition of the brain)
- The blood-brain barrier protects the brain from chemical intrusion from the rest of the body

Peripheral Nervous System (PNS)

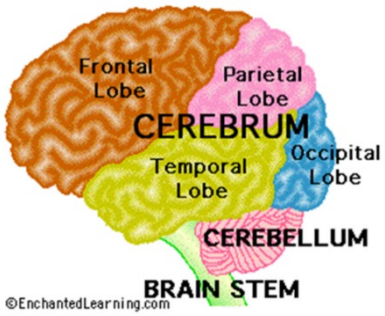
The peripheral nervous system is a collective term for the nervous system structures that do not lie within the CNS. It consists of *the cranial nerves*, *the spinal nerves*. The PNS is divided into somatic and visceral parts. The somatic nervous system consists of the nerves that innervate the skin, joints, and muscles. The visceral part is also known as the autonomic nervous system.

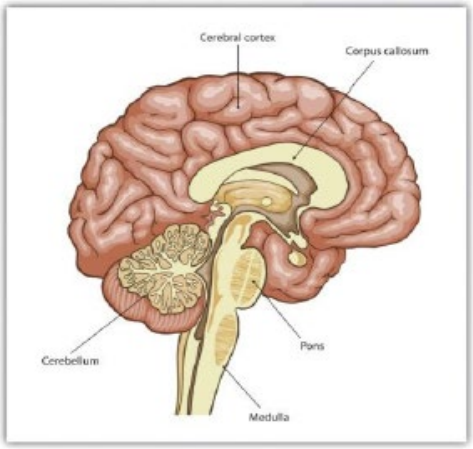
Central Nervous System (CNS)

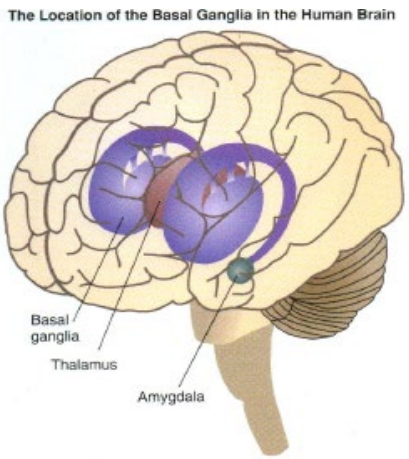
The Brain

The brain consists of gray matter (40%) and white matter (60%) contained within the skull. Brain cells include neurons and glial cells. Although the brain is only 2% of the body's weight, it uses 20% of the oxygen supply and gets 20% of the blood flow. Blood vessels (arteries, capillaries, and veins) supply the brain with oxygen and nourishment and take away wastes. If brain cells do not get oxygen for 3 to 5 minutes, they begin to die.

- The brain has three main parts:
  (1) Cerebrum
  (2) Cerebellum
  (3) Brain stem (medulla oblongata and the pons).



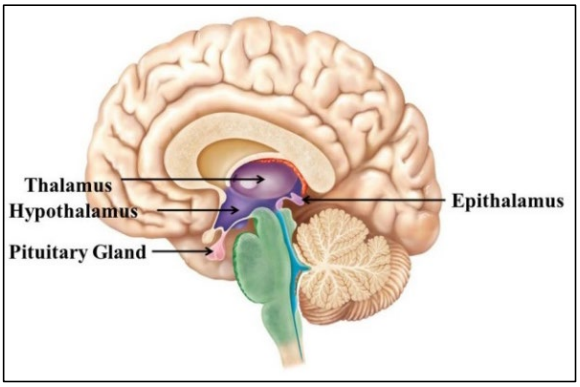




Cerebral hemispheres

It is the largest part of the brain, occupying the anterior and middle cranial fossa in the skull and extending backwards over the tentorium cerebelli. They are made up of:

- The cerebral cortex,
- The basal ganglia,
- Tracts of synaptic connections
- The ventricles containing CSF

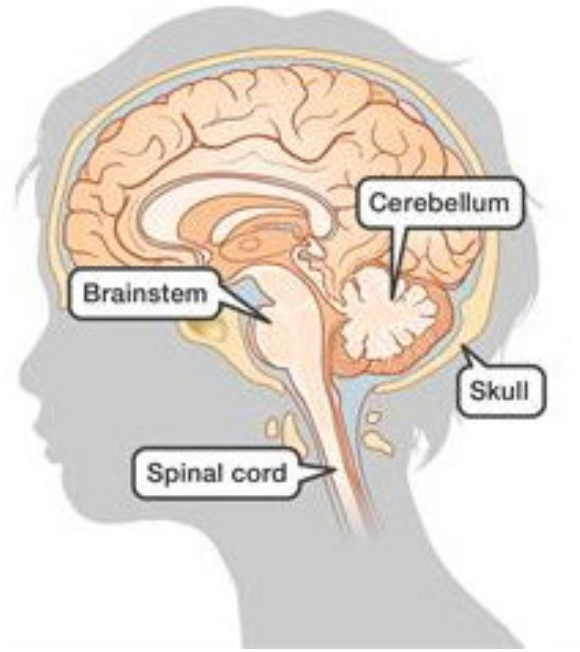


Diencephalon includes

- Thalamus
- Hypothalamus
- Epithalamus
- Sub thalamus

They form the central core of the brain. It is surrounded by the cerebral hemispheres.

It is located at the junction of the middle and posterior cranial fossae



Pons

It sits in the anterior part of the posterior cranial fossa-the fibers within the structure connect one cerebral hemisphere with its opposite cerebella hemisphere.

Medulla Oblongata

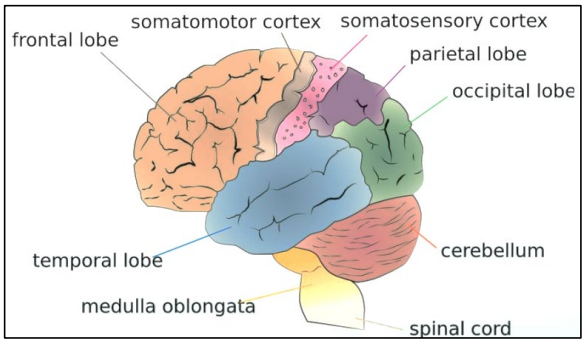
It is continuous with the spinal cord and is responsible for automatic control of the respiratory and cardiovascular systems.

Spinal Cord

The spinal cord is a bundle of nerves that connects the brain to other parts of the body. It is protected in the vertebral column. Spinal cord is the origin of spinal nerves.

The spinal cord has 2 main functions:

1. Control reflexes and activities of the body
2. Transmission of information to and from the brain



Cerebellum

It overlies the pons and medulla, extending beneath the tentorium cerebelli and occupying most of the posterior cranial fossa. It is mainly concerned with motor functions that regulate muscle tone, coordination, and posture.

Brainstem

- It is the lower extension of the brain where it connects to the spinal cord. Neurological functions located in the brainstem include those necessary for survival (breathing, digestion, heart rate, blood pressure) and for arousal (being awake and alert). It includes mid brain, Pons, and medulla oblongata.
- Most of the cranial nerves come from the brainstem. The brainstem is the pathway for all fiber tracts passing up and down from peripheral nerves and spinal cord to the highest parts of the brain.

Functions and lobes of Cerebrum

1. **The frontal lobe**

It is concerned with higher intellectual functions, such as abstract thought and reason, speech (Broca's area in the left hemisphere only), olfaction, and emotion. Voluntary movement is controlled in the precentral gyrus (the primary motor area).

2. The parietal lobe

It is dedicated to sensory awareness, particularly in the postcentral gyrus (the primary sensory area).It is also concerns with abstract reasoning, language interpretation and formation of a mental egocentric map of the surrounding area.

3. The occipital lobe

It is responsible for interpretation and processing of visual stimuli from the optic nerves, and association of these stimuli with other nervous inputs and memories.

4. The temporal lobe

It is concerned with emotional development and formation, and also contains the auditory area responsible for processing and discrimination of sound. It is also the area thought to be responsible for the formation and processing of memories.

Blood supply

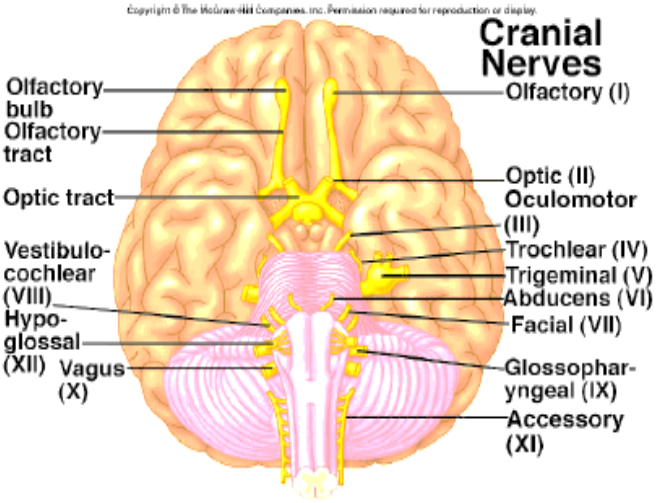
(1) Anterior cerebral artery (2) Middle cerebral artery (3) Posterior cerebral artery

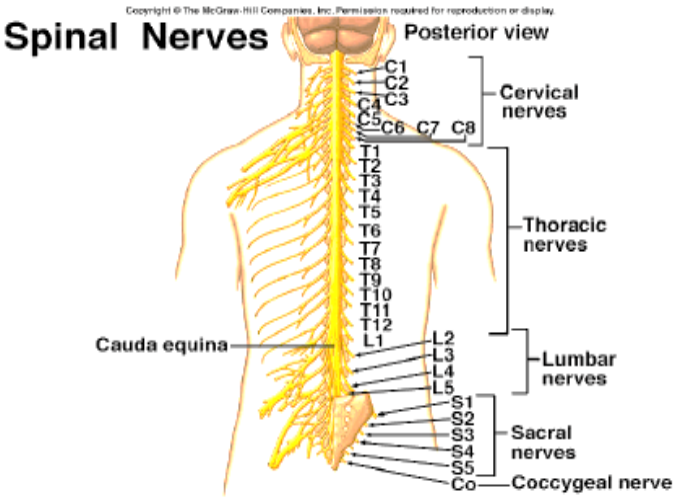
Stenosis or occlusion in any of these arteries will have an effect on the area of brain they supply; the effect will depend on the degree and site of occlusion.

Peripheral Nervous System (PNS)

Cranial nerves

Nerve	Function
I nerve	Sense of smell
II nerve	Vision
III, IV, VI nerve	Eye movement and papillary size
V nerve	Sensation of face, mouth, lip, eye, forehead and anterior part of scalp / movement of the jaw, initiation and coordination of swallowing
VII nerve	Movement of facial muscles; taste on the anterior two third of the tongue
VIII nerve	Hearing
IX nerve	Sensation of pharynx and posterior third of the tongue
X nerve	Phonation, movements of palate and posterior pharyngeal wall. palatal and pharyngeal Reflexes
XI nerve	Sternomastoid and upper trapezius muscles
XII nerve	Tongue movement





Spinal Nerves

Spinal nerves take their origins from the spinal cord. From the spinal cord, they pass through the holes between and beside the vertebrae called spinal canals.

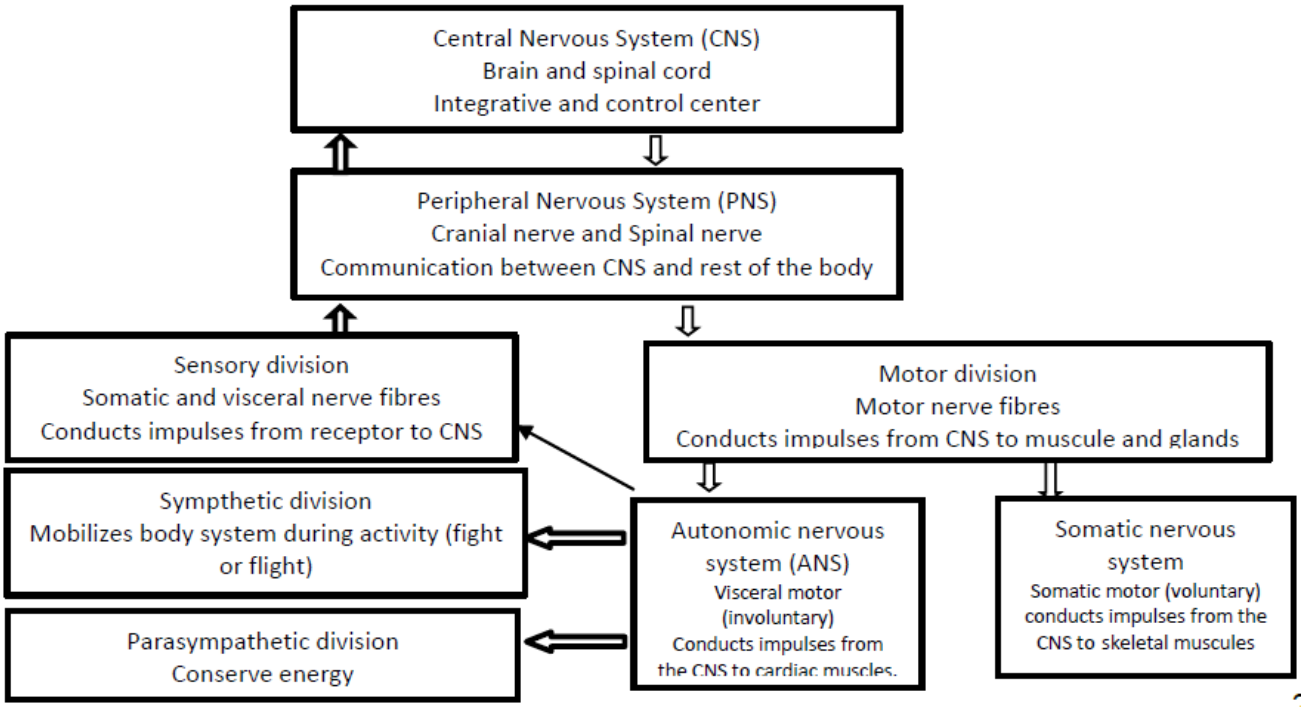
There are 31 pairs of spinal nerves. The nerves are called according to the vertebral level they are connected with. They are:

- 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, 1 coccygeal.

They control the functions of the rest of the body. The nerves are divided into 3 branches.

1. A *dorsal branch* goes at the skin and muscles of the back part of the body.
2. A *ventral branch* goes to the front part and is usually connected with other spinal nerves to form plexuses that give off other nerves.
3. An *autonomic branch* goes to the organs and regulates autonomic life: larynx, trachea, lungs, heart, gallbladder, and digestive system.

Function of Nervous System

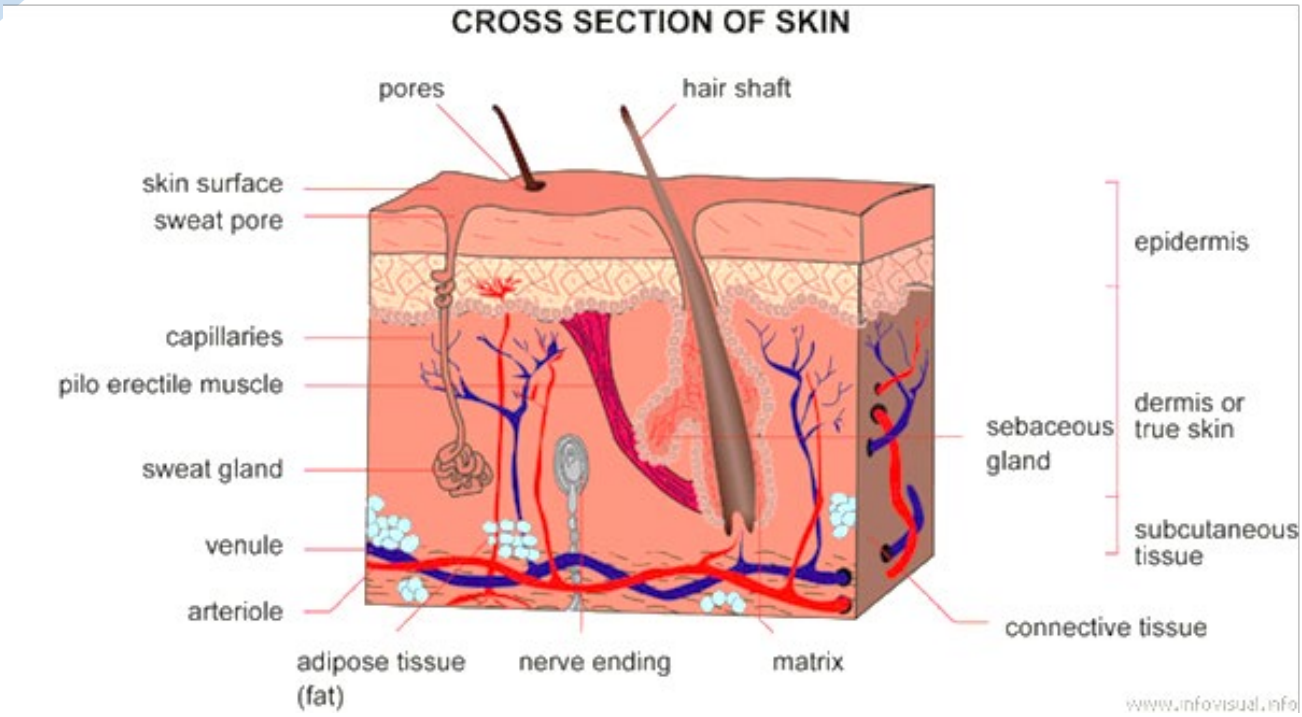


The autonomic nervous system

It contains neurons that innervate the internal organs, blood vessels, and glands. The autonomic nervous system split into three parts: sympathetic, parasympathetic and enteric nervous systems.

The *sympathetic nervous system* is responsible for the "fight or flight" responses. It responds to the excitement (e.g., impending danger) making heartbeat and blood pressure increase due to the increase of adrenaline hormone. It slows down the digestive system so that more blood is available to carry oxygen to the vital organs such as brain, heart and muscles.

The *parasympathetic nervous system* is responsible for the “rest and digest” responses. It responds to the condition when a person is resting and feels relaxed making the heartbeat slow, the dilation of the blood vessels, and the stimulation of the digestive & genitourinary systems and the constriction of the pupil.



Anatomy

Blood vessels - Tubes that carry blood as it circulates. Arteries bring oxygenated blood from the heart and lungs; veins return oxygen-depleted blood back to the heart and lungs.
Dermis - (also called the cutis) the layer of the skin just beneath the epidermis.
Epidermis - the outer layer of the skin.
Hair follicle - a tube-shaped sheath that surrounds the part of the hair that is under the skin. It is located in the epidermis and the dermis. The hair is nourished by the follicle at its base (this is also where the hair grows).
Hair shaft - The part of the hair that is above the skin.
Hair erector muscle - a muscle is connected to each hair follicle and the skin - it contracts (in response to cold, fear, etc.), resulting in an erect hair and a "goosebump."
Melanocyte - a cell in the epidermis that produces melanin (a dark-colored pigment that protects the skin from sunlight).
Pacinian corpuscle - nerve receptors that respond to pressure and vibration; they are oval capsules of sensory nerve fibers located in the subcutaneous fatty tissue
Sebaceous gland - a small, sack-shaped gland that releases oily (fatty) liquids onto the hair follicle (the oil lubricated and softens the skin). These glands are located in the dermis, usually next to hair follicles.
Sweat gland - (also called sudoriferous gland) a tube-shaped gland that produces perspiration (sweat). The gland is located in the epidermis; it releases sweat onto the skin.
Subcutaneous tissue - fatty tissue located under the dermis.

Functions of the Skin

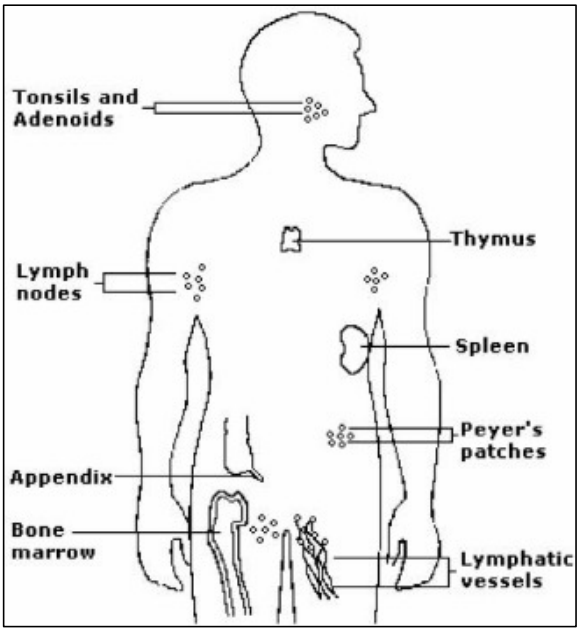
- **Protection**: an anatomical barrier from pathogens and damage between the internal and external environment in bodily defense; Langerhans cells in the skin are part of the adaptive immune system
- **Sensation**: contains a variety of nerve endings that react to heat and cold, touch, pressure, vibration, and tissue injury
- **Heat regulation**: the skin contains a blood supply far greater than its requirements which allows precise control of energy loss by radiation, convection and conduction. Dilated blood vessels increase perfusion and heat loss, while constricted vessels greatly reduce cutaneous blood flow and conserve heat. Erector pili muscles are significant in humans.
- **Control of evaporation**: the skin provides a relatively dry and semi-impermeable barrier to fluid loss.
- **Storage and synthesis**: acts as a storage center for lipids and water
- **Absorption**: Some chemicals can be absorbed through the skin.
- **Water resistance**: The skin acts as a water-resistant barrier so essential nutrients aren't washed out of the body.

IMMUNE SYSTEM

The immune system is a complex of cells, tissues and organs, all of which working together to clear infection from the body. The organs/tissues of the immune system, positioned throughout the body, are called lymphoid organs/tissues.

The organs and tissues of the immune system are:

- Lymphatic vessels and lymph nodes
- Spleen
- The bone marrow
- Lymphoid tissues



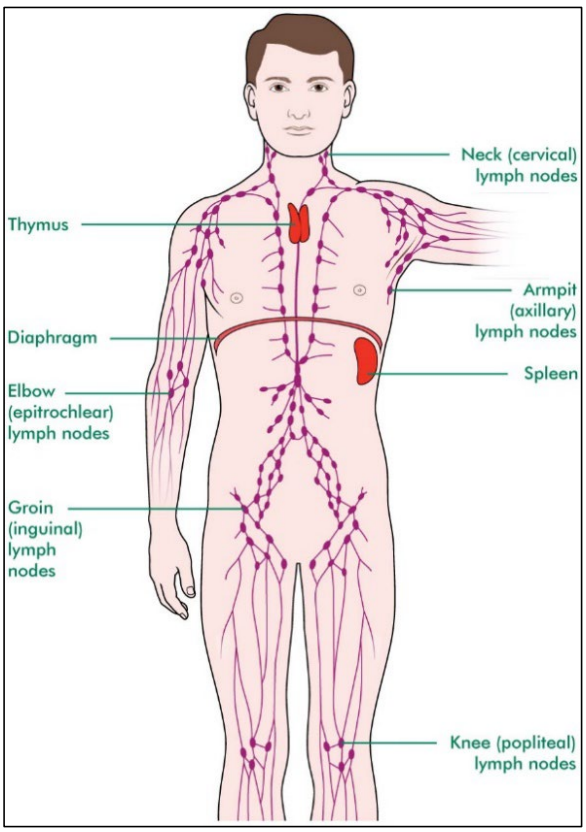
Anatomy

Lymphatic vessels and lymph nodes

Lymphatic vessels and lymph nodes are the parts of the special circulatory system that carries **lymph.** Lymph is a transparent body fluid containing white blood cells. Lymphatic vessels form a circulatory system that operates in close partnership with blood circulation. Lymph nodes are found throughout the body. Lymph nodes connect the network of lymphatic vessels and provide meeting grounds for the immune system cells that defend against invaders.

Examples

- Cervical lymph nodes located on the neck
- Axillary lymph nodes located under the arm
- Inguinal lymph nodes located in the groin
- Intra-abdominal lymph nodes located in the abdominal cavity



Spleen

The spleen is an organ located at the upper left of the abdomen. The spleen is an immunologic filter of the blood. Old red blood cells are also destroyed in the spleen.

Bone Marrow

Bone marrow is a spongy tissue found in the center of certain long, flat bones of the body, such as the bones of the pelvis. The bone marrow produces white blood cells that circulate throughout the immune system. White blood cells (leukocytes) are composed of several types of cells – lymphocytes, neutrophils, eosinophils and basophils. Lymphocytes mainly deal with viral infections whereas neutrophils mainly deal with bacterial infections

Lymphoid tissues

Tonsils and adenoids are lymphoid tissues located in the pharynx. The Peyer's patches are lymphoid tissues located in the large intestines.

Physiology

The immune system is the body's defense against infectious organisms and other invaders. Through a series of steps called the immune response, the immune system attacks organisms and substances that invade our body systems and cause diseases.

The lymph nodes and the spleen

The lymph nodes and the spleen function as an immunologic filter of the lymph and blood.

Lymph cleans the tissues of the body, and the lymphatic vessels collect and move it eventually back into the blood circulation.

Before returning the lymph to the circulation, foreign invaders are filtered out of the lymph in the lymph nodes.

The Immune Cells

1) Lymphocytes

B cells and T cells are the major types of lymphocytes involved in the immune system.
B Lymphocytes help in destroying antigen in the body (virus, parasites, bacteria etc.) by producing antibodies. Antibodies are proteins that bind antigens.
T lymphocytes kill other infected cells by releasing toxins.

2) Leucocytes

The innate leukocytes include Natural killer cells, mast cells, eosinophils, basophils and the phagocytes including macrophages, neutrophils and dendrite cell**s.**
Leukocytes surround foreign bodies and destroy them using their powerful enzymes. They are important in the removal of bacteria and parasites from the body.

Both immune cells and foreign molecules enter the lymph nodes via blood vessels or lymphatic vessels. After killing foreign molecules, all immune cells exit the lymphatic system and eventually, return to the bloodstream. Once they get back in the bloodstream, lymphocytes are transported to tissues throughout the body and act as guard to lookout for foreign invaders.

Immunity

Immunity is a condition of being able to avoid infection and communicable disease. Immunity can be either active (acquired) or passive:

Active immunity

The experience of previous infection by a host can lead to the development of immunity towards the same infectious agent. The immunity is developed when the lymphocytes make antibodies in response to the antigen or when the lymphocytes are stimulated against the host. Then, the antibodies and the cells can fight the antigens that cause diseases. A different kind of antibody fights each organism or toxin (antigens). For example, Measles antibodies only fight the Measles virus, but cannot fight Malaria.
When a disease makes a child immune, he has a **natural active immunity** (e.g. when a child had chicken pox once, he is immune to that virus and cannot acquire this disease anymore).When we give him a vaccine to make him immune, he has an **artificial active immunity.**

Passive immunity

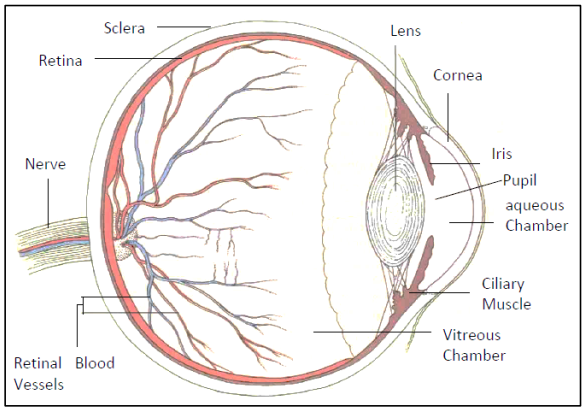
It is the transfer of active immunity through ready-made antibodies from other source. (For example, the maternal antibodies can pass through the placenta to the fetus and can protect the fetus. Some antibodies can also pass through breast milk to protect the newborn against infection.) The immunity can also be induced artificially by the administration of an antibody-containing preparation (antiserum or immune globulin).

Herd immunity

This is the development of a form of immunity that happens when the vaccination of a significant portion of a population gives protection to the whole community. (For example, we can prevent Measles, Polio, and Whooping cough from spreading in a community by immunizing more than 90 per cent of its children. The immunized children give the whole community a 'herd immunity', because the proportion of non-immunized children is too low to let the organisms live in that community. There is no one around to transmit infection, even for people who are not vaccinated.)

THE EYE

Basic Anatomy and Physiology



The eye consists of an eyeball, which can move, in all directions because of the coordinated work of various muscles attached to the external layer of the eyeball. The eyeball is made up of various layers:

Outside: Sclera: the "white of the eye" covering the entire eye except the anterior colored portion (iris and pupil) where it joins the cornea: the window of the eye.

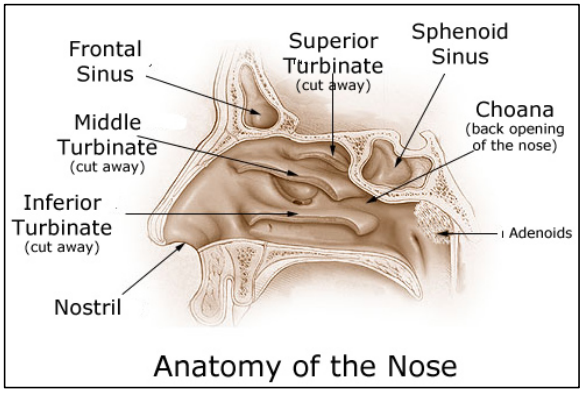
Inside: Retina: containing sensory receptors (including receptors specialized to analyze colors) sending visual information through the optic nerve to the visual area located in the back part of the brain.

- The eye can be compared to a camera with:
- It's lens, which accommodates according to the distances.
- It's pupil, which regulates the quantity of light coming in the eye.

It's retina, which can be compared to the light sensitive film used in a camera.

THE NOSE

Basic Anatomy and Physiology



The nose is the initial part of the respiratory tract and an organ of sense of smell. It is a large irregular cavity divided into two by the septum. The nose is separated from the mouth by the palate – hard palate at the front and soft palate at the back.

The nose is also connected to the maxillary sinus.

Sinuses are cavities in the bones of the face and head on each side of the nose and above the nose. Normally, sinuses contain only air.

The nasolacrimal duct is a channel about 2cm long between the lower part of the eye and the nasal cavity. In the nasolacrimal duct, tears from the eyes can drain into the nose.

The lining of the nose is mucous membrane containing hair cells and mucus cells. The mucus membrane contains a large number of blood vessels and sensory nerves. It is important for respiratory function and for the sense of smell.

Functions

Respiratory Function

Warm, wet and clean air before it enters the lungs.

Sense of Smell

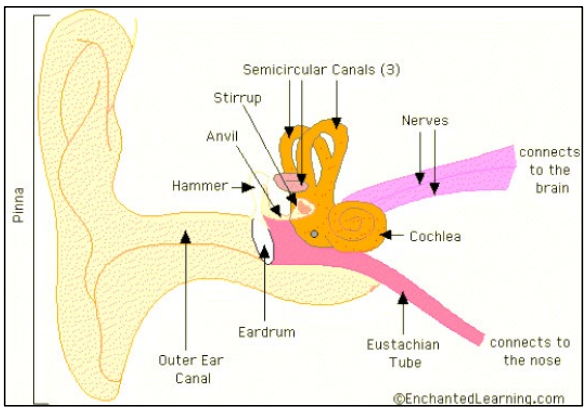
Smells come from chemical substances. The chemicals stimulate nerves in the mucus membrane of the nose. Nerve impulses are transmitted to the brain in the olfactory nerve. The olfactory area of the brain analyses the impulse so that we know what we smell.

Sinuses

Para-nasal Sinuses

THE EAR

Basis Anatomy and Physiology



The ear is a sense organ, whose functions are hearing and balance. The ear consists of:

- The **External Ear** includes the part of the auditory canal and we connected to the middle ear.
- The **Middle Ear** with a tympanic membrane and small bones called ossicles. It's connected to the throat through the Eustachian tubes and to the inner ear, which contains the sensory receptors.
- The **Inner Ear** contains two organs that send information to the brain:
  a. Cochlea**:** Hearing organs containing sensory receptors transferring information to the auditory area of the brain through the cochlear nerve.
  b. Semi-circular canals: Organ of balance transmitting information about the position of the body to the brain through the cochlear nerve.

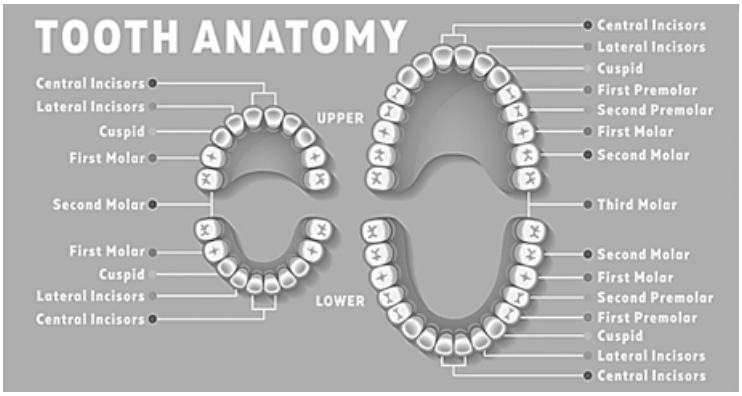
Function

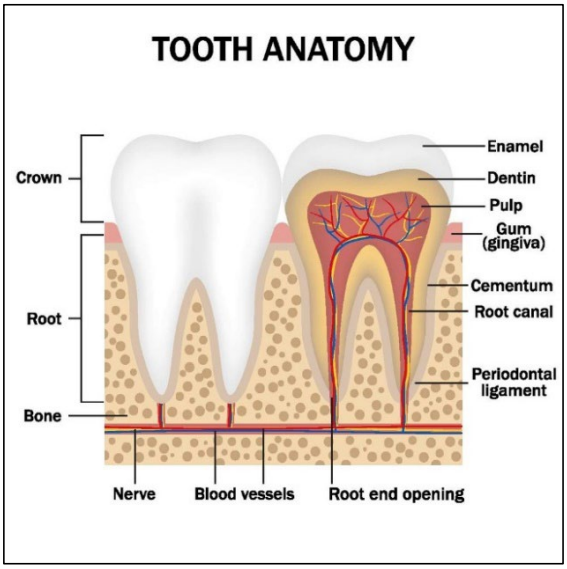
Sound waves enter the auditory cannel and induce vibrations of the tympanic membrane closely connected with the ossicles so that it increases the intensity of the sound waves. It stimulates the sensory cells of the cochlea, which transmit this information to the brain through the cochlear nerve.

THE TEETH

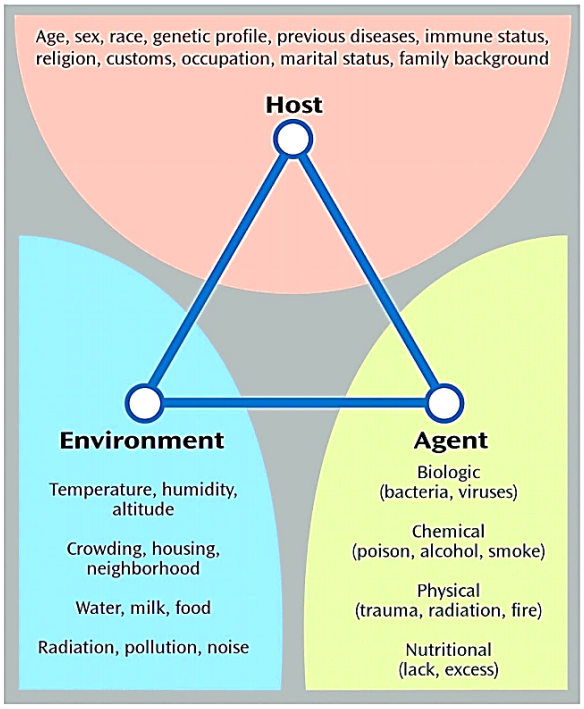
Basic Anatomy and Physiology

- Humans have two sets of teeth: primary and permanent teeth (adult teeth). Primary teeth begin to emerge at around six months of age. Total number is 20.
- Primary teeth fall out and are replaced by 32 permanent teeth (also called the adult teeth).
- This happens over the time from when a child is from about 6 to 14 years old.
- Teeth break down ingested food particles (mastication) with the saliva and the tongue.





INTRODUCTION



A communicable disease results from an infection by microorganisms, such as bacteria, viruses, fungi, and parasites. They result from the interaction of agent, host and environment.

Agent**:** microorganism e.g., bacteria, virus, parasites, etc.

Host and reservoir**:** animal and human infected by the agent

Environment: The factors related

Mode of transmission**:** the way the agent goes from the reservoir to the host.

Transmission of the disease occurs when the microorganism leaves its reservoir or host and enters through an appropriate portal of entry to infect a susceptible host.

After an agent exits its natural reservoir, it may be transmitted to a susceptible host in numerous ways:

Direct transmission**:**

- direct contact (kissing, skin-to-skin contact, blood, sexual intercourse, soil)
- droplets spread (sneezing, coughing, talking)

Indirect transmission**:**

- Airborne transmission is by particles that are suspended in air: (e.g., TB)
- Vector borne transmission (Animate intermediaries): flies (Shigella-dysentery), mosquitoes (malaria parasites), fleas (plague bacteria)
- Vehicle borne transmission (Inanimate intermediaries): food, water, blood, fomites (bedding, towels, handkerchiefs, surgical scalpels).

COMMUNICABLE DISEASES

Classification

According to the microorganism

1. Bacterial Infections
2. Viral Infections
3. Fungal Infections
4. Parasitic Infections
5. Protozoa Infections

According to the mode of transmission

1. Fecal-Oral Diseases
1.1. Amoebiasis
1.2. Gastroenteritis
1.3. Cholera
1.4. Shigellosis (Bacillary Dysentery)
1.5. Typhoid & Paratyphoid
1.6. Hepatitis A
1.7. Poliomyelitis
1.8. Enterobius (Pinworm)

2. Respiratory transmission
2.1. Acute Respiratory Infections
2.2. Measles
2.3. Chickenpox
2.4. Tuberculosis
2.5. Acute Rheumatic Fever
2.6. Whooping Cough (Pertussis)
2.7. Diphtheria
2.8. Bacterial Meningitis

3. Soil-Mediated Diseases
3.1. Tetanus
3.2. Ascaris
3.3. Hookworms
3.4. Trichuris (Whipworm)

4. Diseases Transmitted Via Body Fluids
4.1. Syphilis
4.2. Gonorrhea
4.3. Non-Gonococcal Urethritis (NGU)
4.4. Chancroid
4.5. Human Immunodeficiency Virus (HIV)
4.6. Hepatitis B& C

5. Water-Washed Diseases
5.1. Trachoma
5.2. Scabies
5.3. Superficial Fungal Infections

6. Insect-borne Diseases
6.1. Malaria
6.2. Dengue Fever
6.3. Filariasis

7. Food-Borne Diseases
7.1. Food poisoning
7.1.1. Salmonellae
7.1.2. Staphylococci
7.1.3. Clostridia
7.2. Pork Tapeworms
7.3. Beef Tapeworms

8. Domestic Zoonosis
8.1. Rabies
8.2. Leptospirosis
8.3. Anthrax

BACTERIOLOGY

Bacteria are single-cell microorganisms. They typically have few micrometers in length. Bacteria have a wide range of shapes, ranging from spheres to rods and spirals. Bacteria are growing in soil, acidic hot springs, radioactive waste, water, deep in the earth's crust, as well as in organic matter and the live bodies of plants and animals.

There are many bacteria also as the **human normal flora** in the body, especially on the skin and gut. The bacteria in the body are harmless by the protective effects of the immune system, and a few are beneficial.

However, a few species of bacteria are pathogenic and cause infectious diseases including Skin Infections, Scarlet Fever, Leptospirosis, STIs, Tetanus, Typhoid, Scrub Typhoid, Meningitis, Cholera, Tuberculosis, etc. The most common fatal bacterial diseases are Respiratory Infections.

- Bacteria are named and classified by how they can survive and grow, how they are stained in laboratory and what shape they have.
- Gram-positive Bacteria: Gram-positive bacteria are those that are stained crystal violet dye by Gram staining. E.g., Staphylococcus, Streptococcus, Clostridium, etc.
- Gram-negative Bacteria: Gram-negative bacteria are those that do not retain dark blue or violet in Gram staining. E.g., Salmonella, Shigella, Spirochaetes, Neisseria gonorrhoeae, Neisseria meningitis, Hemophilus influenza, etc.
- Aerobic Bacteria: Aerobic bacteria are organisms that require oxygen for their surviving and growing. E.g., Mycobacterium tuberculosis which causes TB.
- Anaerobic Bacteria: Anaerobic bacteria are organisms that are capable of surviving and growing in an atmosphere of little or no oxygen. E.g., Clostridium which causes Tetanus.
- Some bacteria, such as *Strep. Pyogenes* and *Clostridium tetani,* etc., can produce toxins which are harmful to the human body. There are two kinds of bacterial toxins:
- Exotoxin**:** Exotoxins are released by the bacteria, actively excreted or after lysis of the cell. Most exotoxins can be destroyed by heating.
- Endotoxin**:** Endotoxins are part of the bacteria itself, usually bacterial membrane. It is not released until the bacteria are killed by the immune system. Most endotoxins are heat stable but less potent than exotoxins.

Disease	Organism	Mode of Transmission
Impetigo	Staphylococcus aureus, and sometimes by Streptococcus pyogenes.	Contact, very contagious
Scarlet Fever	exotoxin released by *Streptococcus pyogenes*.	in contact with a person who had *Strep.* Sore throat. The bacteria are spread by respiratory droplets or sharing the same toothbrush. Sometimes, it can be re-infection if recently had *Strep.* Infection.
Leptospirosis	spirochetes called *Leptospira*. These bacteria live in animals especially rats, but also dogs, cats and cattle and are excreted in their urine. Once excreted, they can remain alive in the soil for months.	The contaminated water by animal urine contact with unhealed/ breaks in the skin, the eyes, or with the mucous membranes or close contact with infected animals
Gonorrhea	Neisseria gonorrhea	sexual contact
Syphilis	spirochetes called *Treponema palladium*	through abraded skin at the site of contact, sexual contact, from infected pregnant mother to the fetus
Tetanus	exotoxin produced by *Clostridium tetani*	The toxins (or spores) are widely distributed in soil and animal feces. Infection generally occurs through wound contamination, cut or deep puncture wound, contaminated umbilical cord cutting
Typhoid Fever	Salmonella typhi	contaminated food, water or dirty hands
Scrub Typhus	Orientia Tsutsugamushi (*Rickettsia tsutsugamushi)*	by the bite of a mite living in moist grasslands and jungle. Rodents are normal carrier.
Cholera	epidemic disease caused by *Vibrio cholera*	fecal-oral route (contaminated water, food)
Bacterial Meningitis	mostly caused by Streptococcus pneumoniae, Neisseria meningitidis, Haemophilus influenza and Mycobacterium tuberculosis	mostly inhalation. For Neisseria meningitides, it can be transmitted through saliva and occasionally through close, prolonged general contact with an infected person.
Tuberculosis	mostly by Mycobacterium tuberculosis	air borne from coughing of the patient whose sputum smear is positive (i.e., sputum microscopy reveals AFB)

VIROLOGY

A **virus** is a small infectious agent that can replicate only inside the living cells of organisms. Viruses infect all types of organisms from animals and plants to bacteria**.**

Virus particles (known as *virions*) consist of two or three parts: either **DNA or RNA** molecules that carry genetic information; a **protein coat** that protects these genes; and in some cases, an **envelope** of lipids that surrounds the protein coat when they are outside a cell. The shapes of viruses range from simple to complex structures. The average virus is about one/one-hundredth the size of the average bacterium. Most viruses are too small to be seen directly with a light microscope.

Viruses are spread by coughing and sneezing, faecal-oral route, sexual contact and by exposure to infected blood.

Viral infections provoke an immune response that usually eliminates the infecting virus. Immune responses can also be produced by vaccines, which confer an artificially acquired immunity to the specific viral infection. However, some viruses including those causing AIDS and viral hepatitis evade these immune responses and result in chronic infections. Antibiotics have no effect on viruses, but several antiviral drugs have been developed.

Disease	Organism	Mode of Transmission
Measles	*Measles* virus	Inhalation of respiratory droplets from infected individual
Mumps (Epidemic Parotitis)	*Mumps* virus	contact of respiratory secretion, sharing food and drinks
Rubella (German measles)	*Rubella* virus	air borne droplets
Poliomyelitis	*Polio* virus	fecal-oral route (from contaminated food and water)
Hepatitis	Hepatitis A- Hepatitis A virus, Hepatitis B and C- Hepatitis B and C virus	Hepatitis A – fecal oral route, Hepatitis B and C – direct contact with body fluid especially blood, CSF, vaginal and seminal secretions, mother to child transmission and sexual contact.
Japanese Encephalitis	*Flavi* virus	through the bite of a mosquito (breeds in flooded rice fields)
Chicken pox	*Varicella zoster* virus	air borne through coughing or sneezing, direct contact to secretion from rashes
Herpes	Herpes simplex virus and Varicella zoster virus (Herpes zoster or Shingles)	direct contact with a lesion or infected body fluid. For zoster, it can be latent infection after chicken pox infection.
Dengue Fever	*Dengue* virus	transmitted by the Aedes mosquito bite (these mosquitoes bite during the daytime and are more common in the wet season)
AIDS	Human Immunodeficiency Virus (*Retro* virus)	Sexually, through the infected blood and body fluid and from infected mother to child.
Influenza (Flu)	• Influenza A, B, C, D from Orthomyxoviridae family. • **Swine Flu-** H1N1 subtype of Influenza A virus • **Avian Flu-** H5N1 subtype of Influenza A virus	air borne

MYCOLOGY

Fungus is a simple organism regarded as a plant itself as well as parasite of other plants and animals.

Fungi can cause serious diseases in humans, several of which may be fatal if untreated. These include aspergillosis, candidiasis, cryptococcosis, histoplasmosis, mycetomas etc. Furthermore, persons with immuno-deficiencies are particularly susceptible to disease by *Candida*, *Cryptococcus, Penicilliosis and Histoplasma*.

Other fungi can attack eyes, nails, hair, and especially skin, the so-called dermatophytic and keratinophilic fungi, and cause local infections such as ringworm and athlete's foot. Fungal spores are also a cause of allergies and can evoke allergic reactions.

Some fungi are not harmful and good for medicine e.g., Penicillin was produced from mold.

Candidiasis

Organism: *Candida albicun*, fungal infection of the skin or mucous membranes. Candida yeasts are part of human normal flora, and their growth is controlled by the immune system.

Causes: immunocompromised conditions, disturbance of other normal flora

Risk group: In patients with previous use of antibiotics, diabetes mellitus, decreased immunity or pregnancy

Dermatophytosis (Ringworm)

Organism: *Dermatophytes* (different *Tinea* species) - the fungus surviving on nail, skin and on the outer surface of hairs

MOT: contact (direct or sharing clothing)

PARASITOLOGY

A **parasite** is an organism that lives on or in a host and gets its food from or at the expense of its host. Traditionally, **parasite** referred to organisms with life stages that went beyond one host (e.g., *Taenia solium*), which are now called macro parasites (typically protozoa and helminths) Parasites can cause disease in humans. Some parasitic diseases are easily treated, and some are not.

Helminthes

Helminthes are worm-like organisms that live in living hosts, receiving nourishment and protection while disrupting their hosts' nutrient absorption, causing weakness and disease.

Filariasis

Organism-Thread-like worms - *Wucheria bancrofti*
MOT- By the bite of *Culex* Mosquito

Ascariasis

Organism: parasitic roundworm, *Ascaris lumbricoides*
MOT: fecal-oral route

Protozoa

Protozoa are single-cell organisms existing in aqueous environments and soil. Their size is about micrometers to 1 millimeter so that they can be seen easily with light microscope. They are motile organisms with flagella or cilia or pseupodia.

Malaria

Organism: Plasmodium falciparum (PF), P. vivax (PV), P. malariae (PM), P. ovale (PO)
MOT: By the bite of infected female Anopheles mosquitoes

Amoebiasis

Organism: *Entameba histolytica*, one of the most common protozoan
Reservoir: Humans - usually a chronically ill or asymptomatic cyst passer
MOT: By ingestion of fecally contaminated food or water containing amebic cysts and sexual transmission by oral-anal contact.

BASIC PHARMACOLOGY

Pharmacology is the science of drugs. The aim of learning pharmacology is to understand all aspects of drug actions and effectiveness to develop the beneficial treatment regimens without adverse side effects.

DRUGS

Drugs are chemical substances which are usually used to treat a disease or condition.

Medical Uses of Drugs

1. Therapeutic use
2. Diagnostic use
3. Curative use
4. Replacement use
5. Preventive or Prophylactic use

Drugs Nomenclature

Brand names can change over time as patents expire or companies merge. Most drugs are marketed by numerous names in different countries. Even generic names can differ in different countries. Therefore, there is an international system to identify pharmaceutical substance commonly using the chemical name.
Drugs are identified by one of three names:

1. ***Chemical name:*** long name, refers to the chemical structure of the drug E.g., Acetaminophen
2. ***Generic name:*** shorter preferred name, derived from the chemical name E.g., Paracetamol
3. ***Trade name:*** brand name assigned by the manufacturer E.g., Biogesic

Origins of Drugs

• Plants and Herbs Derivatives
• Opium poppy: juice from seeds yields morphine; powerful painkiller
• Foxglove: leaves contain digoxin; used to treat congestive heart failure (CHF)
  • Can be fatal at high enough doses
• Human Derivatives
  • Hormones
  ○ Insulin-used for diabetes
  ○ Thyroxine-hypothyroidism
  ○ Growth hormone
• Micro-organisms Derivatives
• Antibiotics
  • Penicillin: product of mold
• Synthetic Chemical Derivatives
	These are the chemical modification of the body's own hormones/regulators.
	• Hormonal drugs
	  ○ Estradiol: form of estrogen
	  ○ Prednisolone: synthetic steroid
	• Anti-cancer drugs
	  ○ Drugs used in chemo therapy
	• Recombinant Proteins
	• Hepatitis B vaccine, Influenza vaccine, Tumor markers

Routes of Drugs Administration

A route of administration is the way that a drug, fluid, poison or other substance is brought into contact with the body. There are 3 classifications.
Topical: effect is local, substance is applied externally where it must affect.
Enteral: effect is systemic (non-local), substance is given via the digestive tract
Parenteral: effect is systemic, substance is given internal by other routes than the digestive tract. Most immediate effects are produced by Intravenous, Inhalation and Sublingual routes. Oral drugs need to be taken about 30 minutes before preferable time to get their action. Liquids or powders dissolved in water will act more rapidly than tablets or capsules.

Topical	Per Cutaneous	E.g., Cream, lotion, powder
	Inhalation	E.g., Inhalers for Asthma (Ventolin, Becotide)
	Intranasal	E.g., Nasal Decongestant for nasal polyp
	Eye Drop/Ointment	E.g., Chloramphenicol eye drop, Tetracycline eye ointment
	Ear Drop	E.g., Gentamycin Ear drop
	Per Vagina	E.g., Clotrimazole vaginal pessary
Enteral	Oral	E.g., Paracetamol, Amoxicillin
	Sublingual	E.g., Nitroglycerine, Nifedipine
	Rectal	E.g., Suppositories, enema
Parenteral	Intravenous	E.g., Hydrocortisone injection
	Intramuscular	E.g., Streptomycin injection, Diclofenac injection
	Subcutaneous	E.g., Insulin, Haemopoietin
	Intradermal	E.g., BCG vaccination

Drug Concentration

When the highest level of the drug is circulating through the blood stream, the most intense effects of the drug are gained. This is called Peak Plasma Concentration.

Drugs Classification

According to the availability, drugs can be two types:
1) Over-the-counter (OTC)
2) Prescription (controlled substances)

Different Abbreviations of Drug Prescriptions

tab	tablet
cap	capsule
amp	ampule
syr	syrup
mcg	microgram
mg	milligram
kg	kilogram
IU	International Units
MIU	Million IU
tsp.	teaspoon
am	in the morning
pm	in the afternoon
hs/nocte	at bed time
od	once a day
bid	twice a day
tid/tds	three times a day
qid	four times a day
stat	immediately
prn	as required

q1h(qh) or hrly	every hour
q2h or 2hrly	every 2 hour
q6h or 6hrly	every 6 hours
po	by mouth (oral)
sl	sublingual
pr	per rectum (rectal)
pv	per vagina (vagina)
top	to the affected area (topical)
id	intradermal
sc	subcutaneous injection
im	intramuscular injection
iv	intravenous injection
slow iv	slow intravenous injection
intranasal	intranasal

PHARMACOKINETICS

Pharmacokinetic is the process of how the body acts on the drug. Administered drugs need to be processed by the body into 4 phases. (ADME)

Absorption

Drugs taken by mouth pass to the stomach and then the intestines. They are absorbed from the GI tract into the blood stream and then, distributed through the circulatory system.
Some activity, such as exercise may decrease the absorption of drugs taken by mouth because blood is diverted away from the GI tract to the skeletal muscles during exercises. When the body absorbs less of a drug, the therapeutic effectiveness is decreased.

Distribution

Once the drug is absorbed into the bloodstream, it is distributed to the target sites/tissues, and as well, throughout the body. Drug solubility also affects drug distribution. Drugs with high lipid solubility can easily penetrate the fat areas and cross membrane barriers giving a broader distribution. E.g. Lipid-soluble drugs can easily pass through the blood-brain barrier to affect the CNS.
Exercise increases the distribution of most drugs.

Metabolism

This is the clearing process that breaks down drugs/chemical substances into water soluble form for easy elimination. The drugs are mainly metabolized in the liver and also in the kidney, gastro-intestinal tract and the lungs.

Excretion

Drug compounds and their metabolites need to be removed from the body via excretion. If excretion is not complete, accumulation of these metabolites can adversely affect the normal metabolism of the body. The **kidney** is the most important site where metabolites are excreted through urine. Another way to excrete the substance is from the liver to the gut through biliary excretion, with final excretion in the feces. For some anesthetic gases, the excretion can be done is through the **lungs**.
Excretion rate also affects the **drug's half-life**. Half-life is the time required for the body to eliminate one-half of a dosage of a drug by regular, physical processes. For example- if a drug has a half-life of 8 hours, it will take 8 hours for the blood concentration of the drug to be decreased by 50%.Water soluble drugs have shorter half-life than lipid soluble drugs. Therefore, water soluble drugs can be easily eliminated from the body. Lipid soluble drugs can be stored in the body providing longest lasting effects.

PHARMACODYNAMICS

Pharmacodynamics is the process of how the drug acts on the body.

How do Drugs Work?

For drugs to work, they must bind to the receptor of the target either to activate or deactivate it. The receptor can be a molecule within a cell or on the cell membrane. Relationship between a drug and its receptor is like a "lock and key" configuration. Most drug targets is proteins. Common drug targets include Enzymes, Ion channels, Transporter molecules, etc.

Factors Influencing the Effect of Drug

The effect of drug on the body is influenced by many factors, such as a person's age, genetics and the condition/disorders that person has, etc.…

DRUG INTERACTIONS

Drug Interaction is the reaction between drugs. Drug interactions can occur between:

- Drug-Drug
- Drug-Food & Beverage
- Drug-Existing Medical Condition

Drug interactions may decrease the effectiveness of a particular drug or increase the action of the drug and can even cause unexpected side effects. Some drug interactions can be harmful to the patient. There are 2 main types of drug interactions.

1. Agonistic/ Synergistic Interaction
2. Antagonistic Interaction

Agonistic Interaction (Additive Effect)

This is the interaction in which the effects of the drug and the other add together.

When two drugs of similar function work together, their combined use can result greater effect than their individual action. This is called Synergistic Interaction.

- The combination of two antibacterial drugs, Trimethoprim and Sulfamethoxazole, makes the very potent bactericidal drug, Co-trimoxazole.
- Aspirin increase the effects of Insulin leading to the risk of hypoglycemia.
- Appetite Suppressant Slimming Pills combined with several cups of Coffee, which are stimulants, cause more palpitations and insomnia than their individual effect.
- Valium and Alcohol, both of which are CNS depressants, can cause severe fatal respiratory depression.
- High dose of Acetaminophen can cause permanent liver damage especially in the underlying Hepatitis or Cirrhosis of Liver patient.

Antagonistic Interaction (Inhibitory Effect)

The effects of the drug and the other have against/cancelled each other. Inhibitory effects may occur with the combination of two unrelated drugs.

- Pyridoxine (B6) inhibits competitively to Isoniazid (INH) by binding the same receptor site so that the side effect of INH, Peripheral Neuropathy, is significantly reduced.
- Rifampicin reduces the effectiveness of oral contraceptives.
- Milk binds up Tetracycline in the stomach and reduces the drug's effectiveness.

ADVERSE DRUGS REACTIONS

Drug dynamics describes the Therapeutic Effects of drugs and also their Side Effects.

Adverse Drugs Reactions range from side effect to hypersensitivity.

1. ***Side Effect*:** side effects are bad responses to medication. They can be mild or severe. E.g., Drowsiness, nausea, and loss of appetite by antibiotics, gastric burning pain by aspirin
2. ***Hypersensitivity*:** The allergic reactions that range from simple rash, itchiness and swelling of skin to anaphylactic reaction. Anaphylactic reaction can occur immediately or be delayed.
3. ***Anaphylactic Reaction*:** It is a severe form of allergic reaction that is life threatening. The patient develops severe shortness of breath or stridor due to bronchial spasm and may stop breathing. Patient can also have cardiovascular collapse called anaphylactic shock. E.g., Penicillin Shock

RESISTANCE OF DRUGS

Drug resistance is the reduction in the effectiveness of a drug in curing a disease or a condition. When the organism is resistant to more than one drug, it is said to be multidrug resistance.

Drug-resistance develops

- Naturally
- With Careless Practices in the use of drugs (i.e., overuse and misuse of drugs)
- By the utilization of low-quality drugs (substandard or counterfeit drugs)
- By the Spread of Resistant Organisms between individuals, communities, and countries.

Increasing problems of drug resistance are very common in poor and marginalized populations because of the difficulty to access quality healthcare in these settings, of liberal use of over-the-counter drugs. Over-the-counter drugs are more likely to create resistance because

- They are often misused; prescribed by unqualified worker and unregistered facility without medical consultation, or self-administered by the patient himself, resulting in inappropriate treatment regimen and length.
- They often follow unofficial procurement channels with the risk to have low quality and less effective/ineffective drugs (counterfeit and substandard drugs).

It is good to keep drugs for domestic use at home for various use of minor illness, but all the prescribed directions and expiry dates should be monitored carefully. To reduce further development of drug resistance, it is important to encourage communities and patients to be treated in registered health facilities and by skilled health workers. It is also important that health workers prescribe the appropriate treatment and avoid over-use of antibiotics. Today, urgent and coordinated action is required at local, national, and international levels to ensure the adequate treatment of patients to preserve the life-saving power of antimicrobial drugs for the future generations.

Precaution of Drugs Used in Pregnancy

Possible to use	Do not use during 1st trimester	Avoid	Contraindication
Cephalosporin Metronidazole	Albendazole Mebendazole Praziquantel Artesunate Carbamazepine Nifedipine Pyrazinamide Sodium valproate	Amitriptyline Chlorpromazine Ciprofloxacin Diazepam Efavirenz Fluconazole Fluoxetine Haloperidol Isosorbide dinitrate Mefloquine Phenobarbitone Phenytoin Hydrochlorothiazide	Aspirin BCG Enalapril Depo Diclofenac Doxycycline Ibuprofen Gliclazide Mefenamic acid Spironolactone Primaquine Spironolactone Streptomycin

Drug Therapy for Allergy and Inflammation (Pain)

H1 and H2 receptor inhibitor

H1 Receptor Antagonists – Pharmacological Properties of the selected drugs			
Drugs	Sedative Effects	Antiemetic Effects	Anticholinergic effects
First- Generation Antihistamine			
Chlorpheniramine	**Medium**	**None**	**Medium**
Promethazine	**High**	**High**	**High**
Second – Generation Antihistamine			
Cetirizine	**Low**	**None**	**Very low**

	H1 antagonist (blocker)	**H2 antagonist (blocker)**
Action	Reduce or eliminate effects mediated by histamine, released during allergic reaction	Use to block the action of histamine on parietal cells in the stomach by decreasing the production of ACID by those cells.
Uses	Use in treatment of Allergic Rhinitis (our term can be common cold), Allergic Conjunctivitis, dermatological conditions (allergic), Urticaria, Nausea/Vomiting, Pruritus (insect bites), Sedation	For dyspepsia, Peptic Ulcers, GERD (Gastro-esophageal reflux disease) – common term used can be Gastritis. Prevention for stress ulcer.
Side Effect	Sedation, Loss of appetite, nausea, vomiting, epigastric distress, constipation or diarrhea	

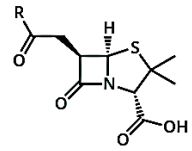
Drugs	Uses	Side Effect	Contraindication
NONSTEROIDAL ANTI-INFLAMMATORY DRUGS (NSAIDs) • Aspirin • Acetaminophen (not really NSAID, but antipyretic, weak analgesic) • Mefenamic acid • Diclofenac. • Ibuprofen	• These drugs usually are effective against pain of low-to moderate intensity, such as dental pain. • Pain arising from the hollow viscera usually is not relieved. An exception to this is menstrual pain. • NSAIDs find their chief clinical application as anti-inflammatory agents in the treatment of musculoskeletal disorders, such as rheumatoid arthritis and osteoarthritis	• Abdominal pain • Gastric erosions/ulcers • Anemia • GI hemorrhage • Perforation • Diarrhea • Renal Salt and water retention, Edema, worsening of renal function in renal/cardiac and cirrhotic patients • Hyperkalemia • CNS Headache, Vertigo, Dizziness, Confusion, Depression • Inhibit platelet activation • Asthma • Urticaria • Flushing • Hypotension • Shock	• Don't combine aspirin and other NSAID • Not use in pregnancy first 6 months • Avoid in lactating mother
Corticosteroid: • glucocorticoids (Dexamethasone, Hydrocortisone and Prednisolone etc.) are powerful anti-inflammatory and Immuno suppressant.	• arthritis (Ex: rheumatoid arthritis), • colitis (Ex; ulcerative colitis, and Crohn's disease), • asthma and bronchitis, • some of the situations involving skin rashes, • allergic or inflammatory conditions involving the nose and eyes		• Active Tuberculosis, peptic ulcer, uncontrolled bacterial/parasitic infection, acute viral infection
Tramadol *Tab 50mg, amp 50mg*	• moderate acute pain, moderate to severe chronic pain, neuropathic pain	• Dizziness, nausea, drowsiness, allergic reaction, withdrawal symptoms, headache, hypotension, constipation	• Severe respiratory depression, patient with risk of seizure, careful with severe renal or liver disease
Adrenaline (epinephrine) 1mg/ml, 1 ml amp	• anaphylactic shock, severe allergic reactions, cardiac arrest, severe asthma or croup	• arrhythmia	• Ischemic heart disease, hypertension, hyperthyroidism, careful in diabetes

Mineralocorticoid's (salt retaining) that regulate the balance of salt and water in the body.
E.g. – Aldosterone

Anaesthetic Drug	Indication	Dosage	Side Effect	Contraindication
Atropine Sulfate 0.6mg/ml, 1 ml ampule	Anesthesia, bradycardia, spasm of GI/bile duct	0.25-1 mg SC or IV	Urine retention, dryness of mouth, constipation, dizziness, headache, dilatation of pupils, tachycardia	Urethra-prostatic disorders, cardiac disorders, glaucoma, child with high fever, avoid in breast feeding
Lidocaine (xylocaine) 1%-10mg/ml, 20 ml vial *Lidocaine 2% with adrenaline(epinephrine 1/80,000, 1.8 ml (for dental)*	Local anesthesia for trauma, incision, suturing or procedure for treatment or investigation.	Max 5mg/kg; adult 200mg IM or SC (1%: 200mg in 20 ml and 2%; 200mg in 10 ml)	no	Allergy to lidocaine, impaired cardiac conduction

ß-LACTAMS

MOST WIDELY USED ANTIBIOTICS IN THE NHS



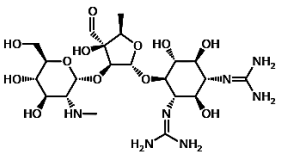
All contain a beta-lactam ring

EXAMPLES
Penicillins (shown) such as amoxicillin and flucloxacillin; *Cephalosporins* such as cefalexin.

MODE OF ACTION
Inhibit bacteria cell wall biosynthesis.

AMINOGLYCOSIDES

FAMILY OF OVER 20 ANTIBIOTICS



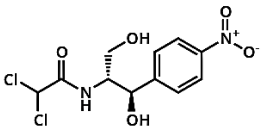
All contain aminosugar substructures

EXAMPLES
Streptomycin (shown), neomycin, kanamycin, paromomycin.

MODE OF ACTION
Inhibit the synthesis of proteins by bacteria, leading to cell death.

CHLORAMPHENICOL

COMMONLY USED IN LOW INCOME COUNTRIES



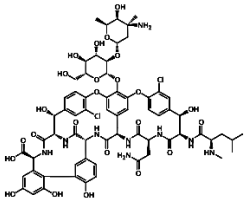
Distinct individual compound

MODE OF ACTION
Inhibit synthesis of proteins, preventing growth.

No longer a first line drug in any developed nation due to increased resistance and worries about safety.

GLYCOPEPTIDES

COMMON 'DRUGS OF LAST RESORT'



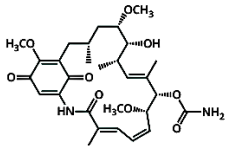
Consist of carbohydrate linked to a peptide formed of amino acids

EXAMPLES
Vancomycin (shown), teicoplanin.

MODE OF ACTION
Inhibit bacteria cell wall biosynthesis.

ANSAMYCINS

CAN ALSO DEMONSTRATE ANTIVIRAL ACTIVITY



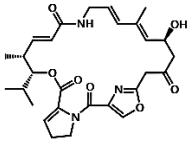
All contain an aromatic ring bridged by an aliphatic chain.

EXAMPLES
Geldanamycin (shown), rifamycin, naphthomycin.

MODE OF ACTION
Inhibit the synthesis of RNA by bacteria, leading to cell death.

STREPTOGRAMINS

TWO GROUPS OF ANTIBIOTICS THAT ACT SYNERGISTICALLY



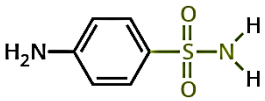
Combination of two structurally differing compounds, from groups denoted A & B

EXAMPLES
Pristinamycin IIA (shown), Pristinamycin IA.

MODE OF ACTION
Inhibit the synthesis of proteins by bacteria, leading to cell death.

SULFONAMIDES

FIRST COMMERCIAL ANTIBIOTICS WERE SULFONAMIDES



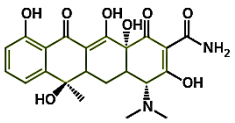
All contain the sulfonamide group

EXAMPLES
Prontosil, sulfanilamide (shown), sulfadiazine, sulfisoxazole.

MODE OF ACTION
Do not kill bacteria but prevent their growth and multiplication. Cause allergic reactions in some patients.

TETRACYCLINES

BECOMING LESS POPULAR DUE TO DEVELOPMENT OF RESISTANCE



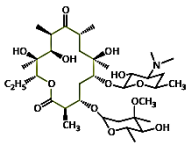
All contain 4 adjacent cyclic hydrocarbon rings

EXAMPLES
Tetracycline (shown), doxycycline, limecycline, oxytetracycline.

MODE OF ACTION
Inhibit synthesis of proteins by bacteria, preventing growth.

MACROLIDES

SECOND MOST PRESCRIBED ANTIBIOTICS IN THE NHS



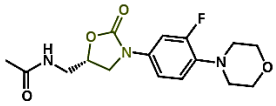
All contain a 14-, 15-, or 16-membered macrolide ring

EXAMPLES
Erythromycin (shown), clarithromycin, azithromycin.

MODE OF ACTION
Inhibit protein synthesis by bacteria, occasionally leading to cell death.

OXAZOLIDINONES

POTENT ANTIBIOTICS COMMONLY USED AS 'DRUGS OF LAST RESORT'



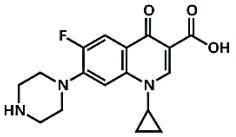
All contain 2-oxazolidone somewhere in their structure

EXAMPLES
Linezolid (shown), posizolid, tedizolid, cycloserine.

MODE OF ACTION
Inhibit synthesis of proteins by bacteria, preventing growth.

QUINOLONES

RESISTANCE EVOLVES RAPIDLY



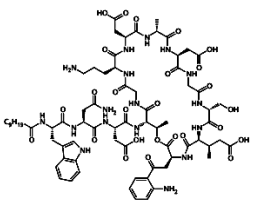
All contain fused aromatic rings with a carboxylic acid group attached

EXAMPLES
Ciprofloxacin (shown), levofloxacin, trovafloxacin.

MODE OF ACTION
Interfere with bacteria DNA replication and transcription.

LIPOPEPTIDES

INSTANCES OF RESISTANCE RARE



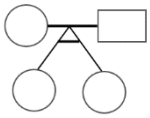
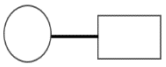
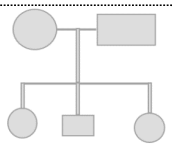
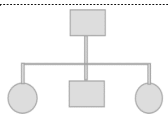
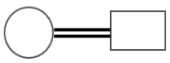
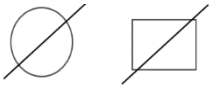
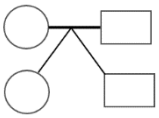
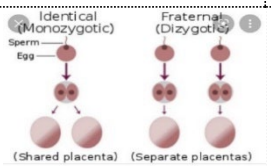
All contain a lipid bonded to a peptide

EXAMPLES
Daptomycin (shown), surfactin.

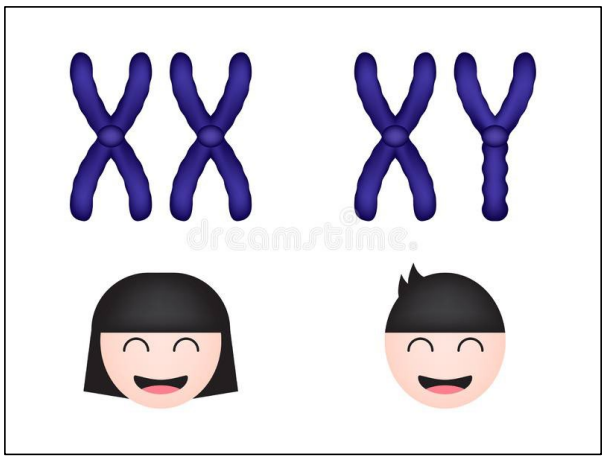
MODE OF ACTION
Disrupt multiple cell membrane functions, leading to cell death.

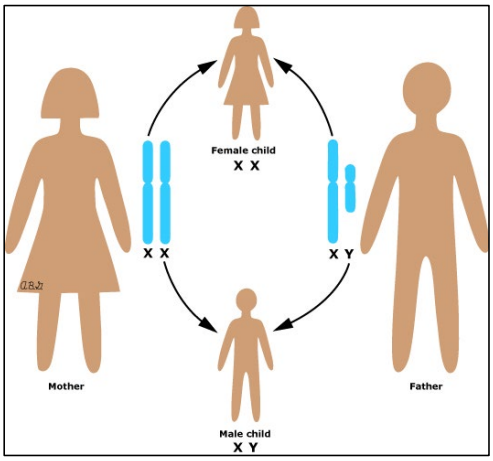
****** Please review detail drugs list in (MTC Medication Hand Book) 2014.**

PEDIGREE

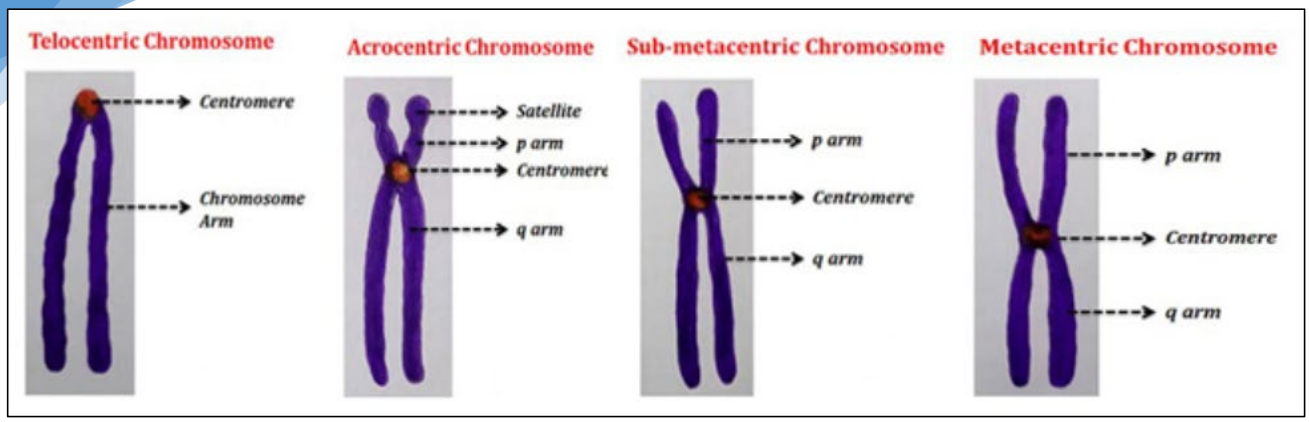
	Normal female		Identical twins
	Normal male		Number of children
	Single bar indicates mating		Affected
	Normal parents and normal offspring		Heterozygote
	Single parent means partner is not significant for the analysis		Female X-linked carrier
	Double bar indicates consanguineous mating		Death
	Fraternal twins (not identical) 		Aborted or stillborn

Humans have 23 pairs of chromosomes. 22 pairs of chromosome, called autosomes, and one pair of sex chromosomes, X and Y. Each parent contributes one chromosome to each pair so that offspring get half of their chromosomes from their mother and half from their father.

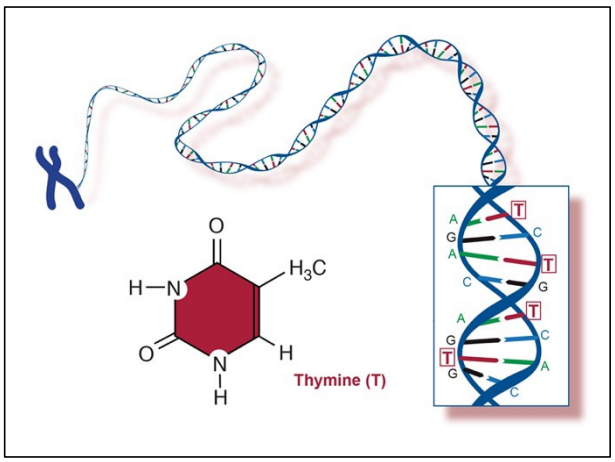


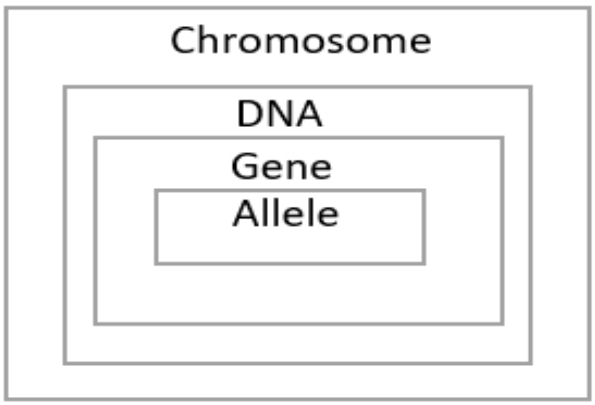


Each chromosome has a constriction point called the centromere, which divides the chromosome into two sections or arms. The short arm of the chromosome is labeled the 'P' arm. The long arm of the chromosome is labeled the 'q' arm.



Human genes are commonly around 27,000 base pairs long, and some are up to 2 million base pairs. A gene is a length of DNA that code for a specific protein. So, for example, one gene will code for the protein insulin which is important role in helping your body to control the amount of sugar in your blood. Genes are the basic unit of genetics. Genes are the segments of DNA. Gene code for a specific protein that code for specific trait. Trait is physical characteristic. One gene in a pair is called allele. Locus is a specific location on a chromosome. A gene is a section of DNA made up of a sequence of **As, Cs, Ts** and **Gs.** The instruction in a gene that tell the cell how to make a specific protein. **A, C, G,** and **T** are the letters of the **DNA** code, they stand for the chemicals Adenine (A), cytosine (C), guanine (G), and thymine (T), respectively, that make up the nucleotide bases of DNA.





Chromosome 1 likely contains 2,000 to 2,100 genes that provide instructions for making proteins. Each DNA molecule contains many genes, the human gene is estimated to certain approximately 8,0000-100,000 genes. The 3 billion base pairs of DNA in the human genome are organized into 23 distinct, physically separate microscopic units called chromosomes.

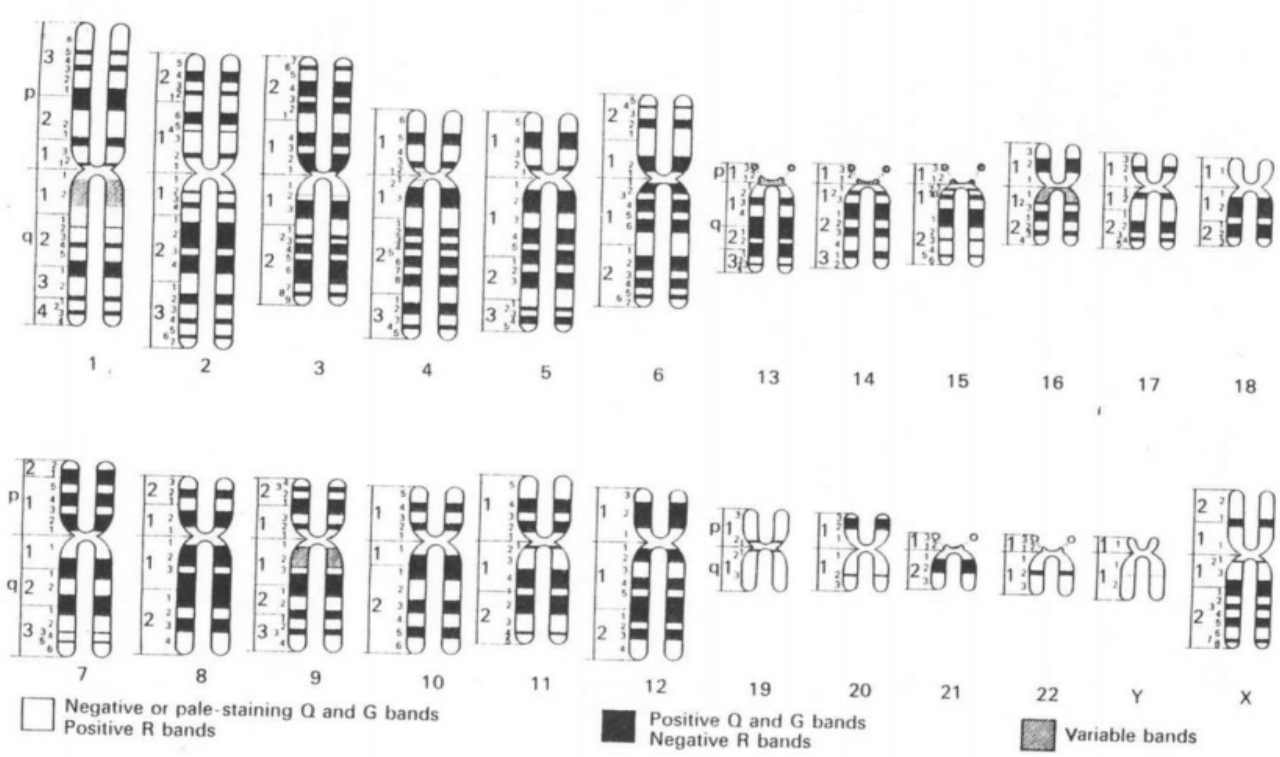


Figure 1.1. Human karyotype, showing a standard numbering system based on chemical staining of a chromosome preparation. Different staining methods yield different levels of detail that are used in refining the system (not shown). (From Thompson and Thompson, 1986.)

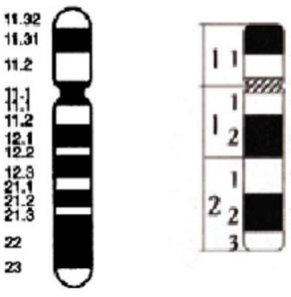
Basic Concepts of Human Genetics

- The genetic information of an individual is contained in 23 pairs of chromosomes. Every human cell contains the 23 pair of chromosomes.
- One pair is called sex chromosomes
  Male: **XY**
  Female: **XX**
- Other 22 pairs of homologous chromosomes are called autosomes.
- The autosome chromosome pairs are called homologous pair. Two chromosomes in the same pair are called homologous chromosomes.

CHROMOSOME BANDING AND NOMENCLATURE

Source: image on left from the GeneMap'99 illustration of Chromosome 18. Image on right from the CCAP Web page on "Recurrent Aberration Data."

Cytogenetic Ideogram for human chromosome 18



Definition

Each human chromosome has a **short arm ("p" for "petit")** and **long arm ("q" for queue")**, separated by a **centromere**. The ends of the chromosome are called **telomeres**.

Each chromosome arm is divided into regions, or **cytogenetic bands,** that can be seen using a microscope and special stains. The cytogenetic bands are labeled p1, p2, p3, q1, q2, q3, etc., counting from the centromere out toward the telomeres. At higher resolutions, sub-bands can be seen within the bands. The sub-bands are also numbered from the centromere out toward the telomere.

For example, the cytogenetic map location of the **CFTR** gene is 7q31.2, which indicates it is on chromosome 7, q arm, band 3, sub-band 1, and sub-sub-band 2.

The ends of the chromosomes are labeled **ptel** and **qtel**. For example, the notation 7qtel refers to the end of the long arm of chromosome 7.

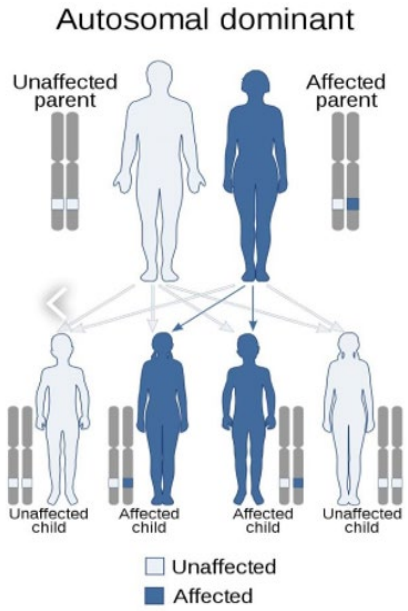
Autosomal Dominant

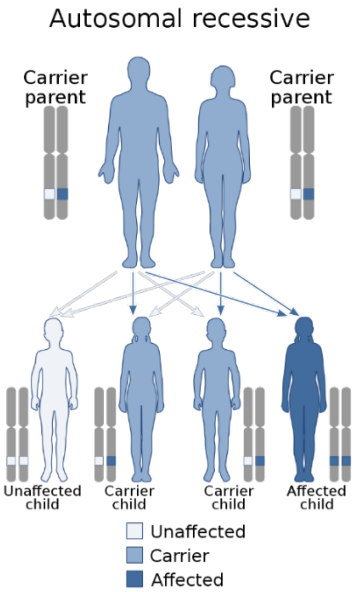
In genetics, dominance is the phenomenon of one variant (allele) of a gene on a chromosome masking or overriding the effect of a different variant of the same gene on the other copy of the chromosome.

Only one mutated copy of the gene will be necessary for a person to be affected by an autosomal dominant disorder. These disorders are inherited when one parent is affected and there is a 50% chance that their offspring will be affected.

Autosomal Recessive

An effect is only apparent when the mutation is present in both alleles. Two copies of the gene must be mutated for a person to be affected by an autosomal recessive disorder. These disorders are inherited from unaffected parents (carries) who both possess one copy of mutated gene and there is, therefore, a 25% chance that their offspring will be affected.





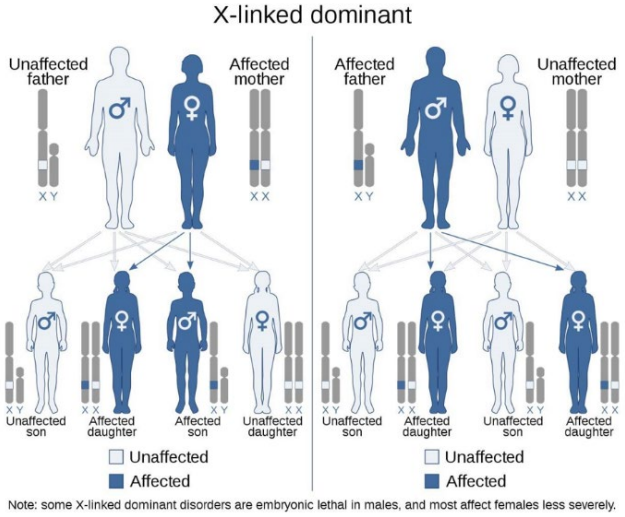
X-linked Dominant

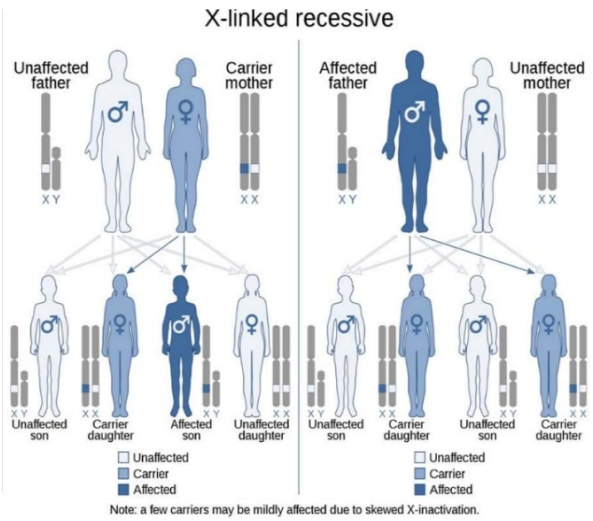
The mutation is in a gene that resides on the **X chromosome**. A gene responsible for a genetic disorder is located on the **X chromosome**, and only one copy of the allele is sufficient to cause the disorder when inherited from a parent who has the disorder. The condition is more common in women. All daughters of an affected, whereas sons will not. Half of the offspring (male or female) of an affected mother are affected.

X-linked Recessive

The condition is more common in men. **X linked recessive** inherited is a mode of inheritance in which a mutation in a gene on the **X chromosome** causes the phenotype to be always expressed in males who have one **X** and one **Y** chromosome. Females with one copy of the mutated gene are carriers.

Therefore, all of the female offspring of an affected male will be carriers. Half of the male offspring of a female carrier are affected. Half of the female carriers are themselves carriers.





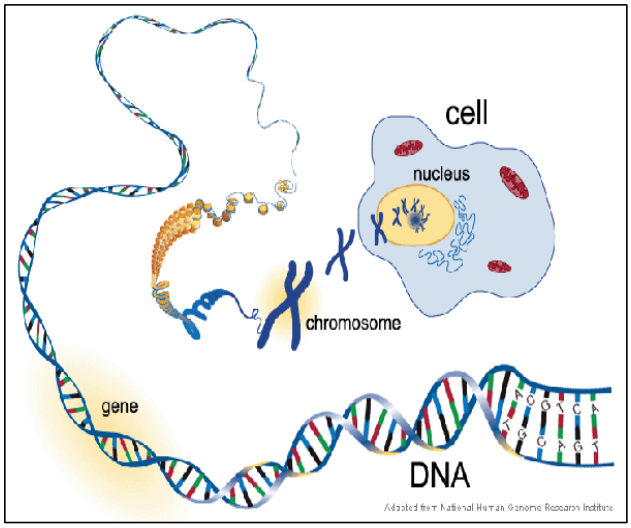
MITOCHONDRIAL DISEASE

Mitochondria are the organelles that generate energy for the cell and are found in every cell of the human body except red blood cell. Mitochondrial disorders may be caused by mutations in mitochondrial DNA or in nuclear genes that code for mitochondrial components.

Examples of mitochondrial diseases include:

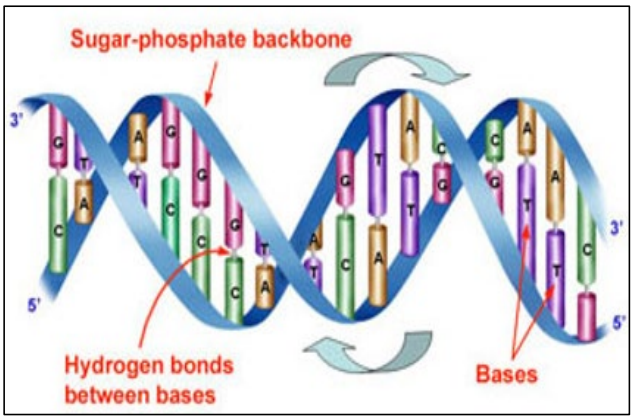
- Mitochondrial myopathy
- Diabetes mellitus and deafness **(DAD)**
- **Leber's** hereditary optic neuropathy
- Leigh Syndrome: Rare genetic neuromuscular disorder which is characterized by the degeneration of the central nervous system.
- Subacute Sclerosing encephalopathy
- Neuropathy, ataxia, retinitis pigmentosa, and Ptosis (NARP)
- **MELAS** Syndrome: Mitochondrial Encephalopathy, Lactic Acidosis, and Stroke-like episodes.

THE UNITS OF HEREDITY



- Genes are the units of heredity and are the instructions that make up the body's blueprint. They code for the proteins that determine virtually all of a person's characteristics.
- Humans have an estimated 35,000 genes.
- Most genes come in pairs and are made of strands of genetic material called ***deoxyribonucleic acid***, or ***DNA.***
- Genetic disorders are caused by one or more changes, or ***mutations***, in the instruction code of a particular gene(s), preventing the gene(s) from functioning properly.
- The study of human genetics is the study of human variation that is carried in the genes.
- The physical location of a gene is its ***locus***. Different versions of genes are called ***alleles***. For example, an eye color gene may have a blue allele and a brown allele.
- Genes are organized in structures called ***chromosomes***.

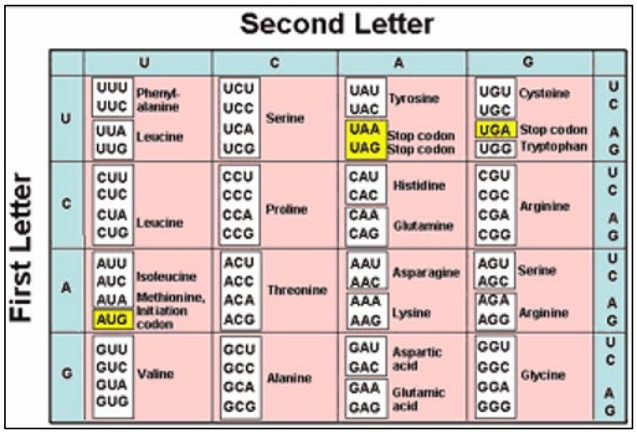
STRUCTURE OF DNA

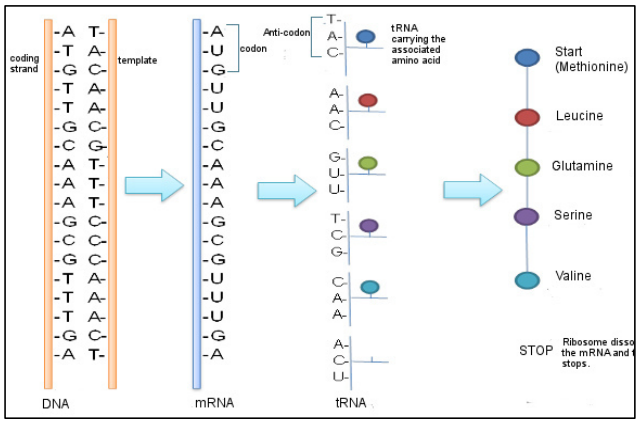


- The DNA molecule is a double helix, and it is composed of three main parts:
  - Five-carbon sugar (deoxyribose)
  - Phosphate molecule
  - One of four nitrogen-containing bases
    - Adenine (A)
    - Guanine (G)
    - Cytosine (C)
    - Thymine (T)
- The double helix is a ladder. Two anti-parallel are comprised of sugars and phosphates, and the bases comprise the "rungs" of the "ladder."
- The message encode in DNA is made up of the four-letter alphabet A, G, C and T, with each letter representing one of the bases.

CODONS AND BUILDING PROTEINS

- DNA is the code used to produce proteins.
- First, the DNA is replicated, so that there are two identical copies of the DNA. Then, the DNA is transcribed into RNA, which is then translated, or read, by tRNA to make the proteins.
- This process of replication, transcription, and translation, is called the "***central dogma***."
- Just like DNA, RNA is composed of a four-letter alphabet. However, the thymine (T) in DNA is replaced by an uracil (U) in RNA.
- The message encoded in RNA is read in three-letter words called ***codons***.
- Codons code for specific amino acids, which are the building blocks of proteins. Therefore, by knowing the sequence of bases in a gene, it is possible to predict the codons and, ultimately, the amino acid sequence of protein the gene makes.
- There are twenty possible amino acids. However, most amino acids can be coded for by more than one codon.
- The beginning of a coding sequence is signaled by a start codon, a unique sequence for this purpose, the start codon also codes for a methionine.





- There are three codons that indicate the end of the amino acid sequence. These are called stop codons.

Codons and Building Proteins

The RNA message (mRNA) is read in three-letter "words" called ***codons***. According to the instructions in the RNA message, amino acids are added sequentially to create a protein chain as the message is read.

Each codon signals for a certain amino acid to be added to the protein chain. In the example shown the codon '***GUG***' signals for the amino acid valine. Therefore, an RNA message reading '***GUGGAGUUU***' would code for a protein chain of ***valine***, ***glutamic acid***, and ***phenylalanine***.

In order to translate the RNA message (m-RNA), transfer RNA (tRNA) must bring the appropriate amino acid to the mRNA template. The tRNA's contain the complementary RNA code (in the case of ***valine***, ***CAC***). One by one, amino acids are then added together to form a polypeptide chain.

Examples of Genetic Diseases

Disease	Gene/Protein	Common mutation	Effect	Clinical presentation
Autosomal dominant				
Von Willebrand disease type 1	***WWF***: 12p13.3: von Willebrand factor	Various reported: nonsense mutations, missense mutation, and small deletions (frameshift)	Reduction in blood concentration of *WWF*	Typically, mild presentation. Post-surgical bleeding, bruising, and menorrhagia in some patients
Neurofibromatosis type 1	***NF1***: 17q11.2 Neurofibromin 1	Various nonsense mutations leading to production of curtailed neurofibromin protein	Aberrant intracellular Ras signaling due to loss of NF1 tumour suppressor function	Cafe au laic skin spots, axillary, and inguinal freckling, cutaneous neurofibromas, iris Lisch nodules. Central nervous system (CNS) tumours less commonly.

Autosomal dominant, polycystic kidney disease (PKD)	***PKD*** 1:16p13.3 polycystin-1	Various non-conservative missense mutations	Disrupted intracellular calcium signaling; aberrant renal tubule development; growth of fluid-filled renal cysts	Hypertension, cardiac valve defects, liver cysts, kidney stones, aortic aneurysms, end-stage renal disease
Tuberous sclerosis complex (TSC)	***TSC*1:** 9q34: hamartin	Commonly small insertions or deletions	Disrupted function of hamartin-tuberin tumour-suppressor action	Benign tumour growth in brain, kidneys, heart, eyes, lungs, and skin. Seizures, mental retardation, behavior problems
Gilbert's syndrome	***UGT1A1***: 2q37: bilirubin-UDP-glucuronyltransferase (UGT)	Missense mutation in coding region. Also, recessive form caused by promoter mutation	Inability of hepatocytes to process bilirubin	Mild hyperbilirubinaemia, which worsens with stress, dehydration, vigorous exercise and fasting
Achondroplasia	**FGFR3:** 4p 16.3 Fibroblast growth factor receptor (FGFR)	Missense point mutation: G380R	Overactive FGFR3: disturbance of bone growth	Short stature, particularly short upper arms and legs, apnoea, obesity, recurrent ear infections, kyphosis/lordosis
Huntington's disease	***Htt:*** 4p 16.3: Huntington (HTT) protein	**CAG** triplet expansion coding polyglutamine tract 40-50 repeats: adult onset >60 repeats: juvenile onset	HTT protein and cleavage fragments are neurotoxic. Striatal neurodegeneration and progressive global brain atrophy	Reduced motor coordination and subtle disturbance in mood and behavior. Progressive chorea and psychiatric disturbance
Autosomal recessive				
Phenylketonuria	***Pah****:* 12q22: phenylalanine hydroxylase (PAH)	Missense point mutation: R408W	Inability to metabolize dietary phenylalanine due to complete or near complete lack of PAH enzyme function	Toxic build-up of phenylalanine leads to disrupted neurological development, skin abnormalities, and epilepsy and movement disorders.
Cystic fibrosis	**CFTR:** 7q31.2: Cystic fibrosis transmembrane conductance regulator (CFTR)	▲F508:loss of phenylalanine at position 508	Defective apical epithelial chloride channel CFTR protein degraded via cellular quality control mechanisms	Aberrant mucociliary clearance; recurrent respiratory infection; gastrointestinal (GI) and endocrine dysfunction; infertility

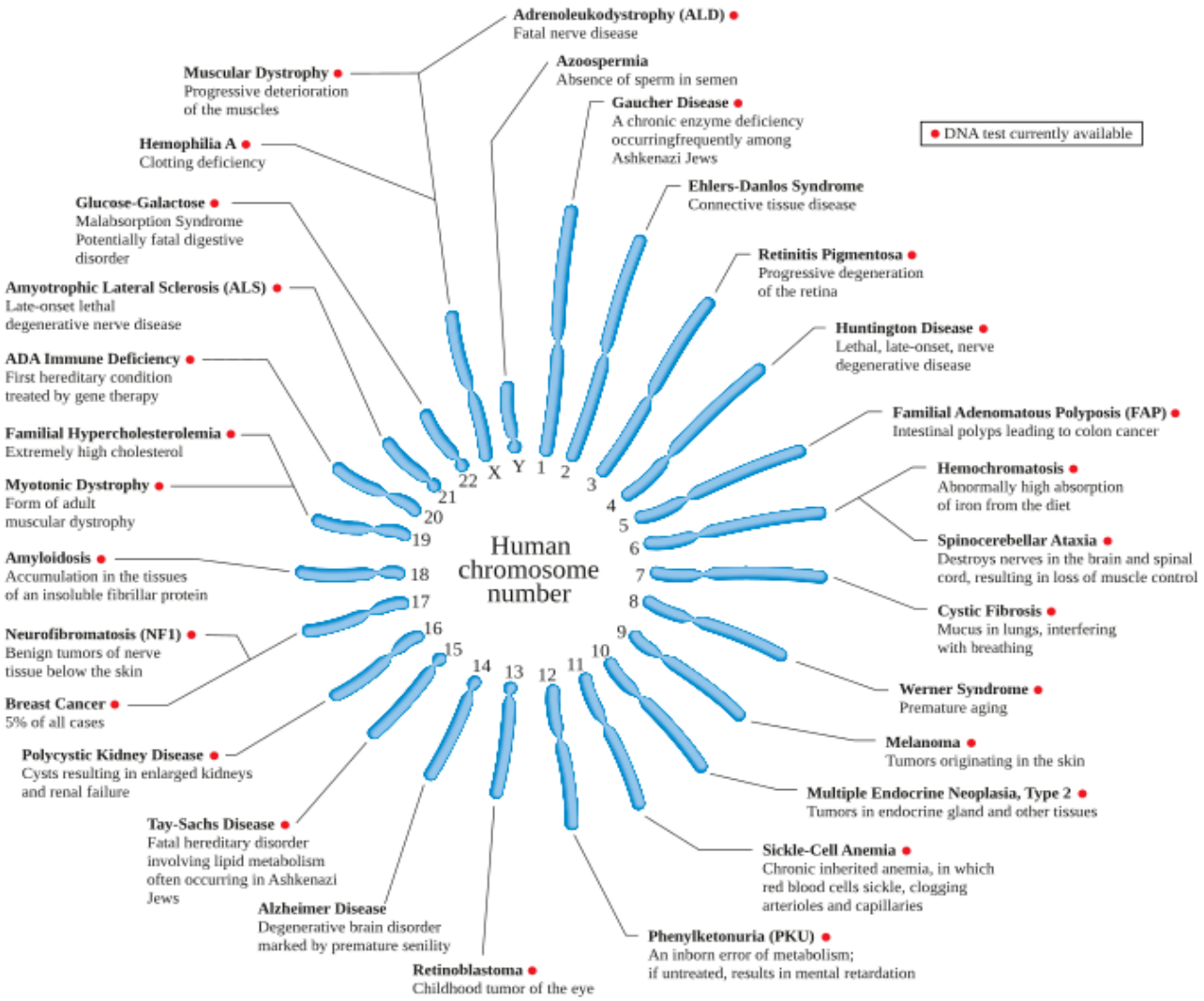
Glycogen storage disease type 1	**G6PC**: 17q21: glucose-6-phosphatase catalytic subunit SLC37A4: 11q23:3 glucose-6-phosphate transporter	Mainly missense/nonsense mutations	Inability to break down glucose, leading to excessive glycogen and fat production for intracellular storage. Build-up damages tissues, especially kidneys and liver	Presents at 3-4 months. Hypoglycaemia, seizures, lactic acidosis, hyperuricemia, hyperlipidemia, enlarged liver/kidneys, xanthomas, diarrhoea. Short stature and thin arms/legs
Recessive/dominant forms				
Alpha-1 antitrypsin deficiency	Serpina 1: 14q32.1: alpha-1 antiproteinase	Various non-conservative missense mutations	Deficient or dysfunctional alpha-1 antiproteinase leading to lung damage due to excessive exposure to neutrophil elastase	Stimulation of immune responses in the lungs and ensuing neutrophil elastase production can lead to early onset emphysema and COPD
Sickle cell anaemia	***Hbb**:* 11p15.5 Haemoglobin-beta	Missense point mutation: E6V	Production of abnormal Hb subunits, which accumulate to produce long, rigid complexes, leading to sickling of erythrocytes	Anaemia due to haemolysis of sick-cell. Vaso-occlusive crisis and splenic sequestration crisis due to reduced deformity of RBCs and aggregation in small vessels
Trinudeotide repeat				
Fragile X syndrome	5'UTR of *Fmr1*: Xq27.3	CGG triplet expansion extending into Fmr1 promotor. >200 repeats symptomatic	*Transcriptional silencing of FMR1 protein:* regulator of translation and synaptic plasticity in the CNS	*Males:* moderate-severe mental retardation, characteristic facial features, large testes. *Females:* milder learning disability; 50% penetrant
Myotonic dystrophy	3'UTR of *Dmpk* and promoter of *Dmahp*: 19q13.3	CTG triplet expansion. *50-80 repeats:* asymptomatic. *40-160 repeats*: mild disease. *65-1200 repeats:* adult onset. *500-2500 repeats:* congenital.	Broad splicing defects due to transcription factor sequestration by triplet expansion in mRNA	Myotonia, posterior iridescent cataracts, cardiomyopathy/conduction defects, abnormal glucose tolerance, hypogammaglobulinaemia
Huntington's disease as above				
X-linked recessive				
Ornithine transcarbamylase deficiency	OTC:Xq21.1: ornithine transcarbamylase			

Duchenne muscular dystrophy (DMD)	*Dmd* gene: Xp21.2: dystrophin	Large deletions	*Absent* protein product: disrupting coupling of skeletal muscle fiber, cytoskeleton, and basal lamina, leading to structural instability	Neuromuscular degenerative disorder: onset at 3-5 years with progression to wheelchair use at around 12 years and eventual respiratory failure
Haemophilia A	*F8*: Xq28: Coagulation Factor VIII	Commonly large inversion. Point mutations and small insertions/deletions reported.	Ineffective clotting cascade	Excessive bleeding, difficult to control and achieve hemostasis
Haemophilia B	*F9:* Xq27.1: Coagulation Factor IX	Point mutations and small insertions/deletions		
X-linked dominant				
Alport syndrome	*COL4A5*: Xq22: Collagen type IV alpha 5 (80% cases)	Mainly missense mutations	Reduces ability of collagen chain to associate with other chains of the same kind. Kidney, inner ear, and eye basement membrane defects leading to scarring	Sensorineural hearing loss in late childhood. Nephritis leading to end stage renal disease. Anterior lenticonus and retinal abnormalities
Fragile X syndrome as above				
Trisomies/monosomies				
Down Syndrome	Trisomy of chromosome 21	Meiotic non-dysjunction event or Robertsonian translocation	Additional copies of genes on chromosome 21	Intellectual disability, hypotonia, cardiac defects, gastroesophageal reflux, underactive thyroid, auditory and visual defects, predisposition to leukaemias
Edwards Syndrome	Trisomy 18	Three copies of chromosome 18.5% mosaicism, but only some cells affected (disease severity varies accordingly)	Additional copies of genes on chromosome 18 in cells disrupts normal development	Heart and other major organ developmental defects. Microcephaly, small, abnormally shaped mouth, and jaw. Clenched fist with overlapping fingers. 5-10% survive beyond 1-year, severe intellectual disability.
Patau Syndrome	Trisomy 13	Three copies of chromosome 13	Additional copies of genes on chromosome 13 in cells disrupts normal development	Heart defects and CNS abnormalities; microphthalmia; cleft lip and cleft palate, hypotonia. 5-10% survive beyond 1 year

Cri-du-chat syndrome	Monosomy of the end of short arm of chromosome 5 (5p)	Size of deletion varies, proportional to disease severity	Loss of specific genes in region of 5p deleted leads to disease presentation. ***CTNND2*** gene specifically implicated in CNS effects	Hypotonia in infancy, low birth weight, microcephaly, intellectual disability, delayed development, hypertelorism, low set ears, rounded face. Increased incidence of heart defects.
Klinefelter Syndrome	Trisomy: 47.XXY	Additional copy of X chromosome in cells of affected males	Additional copies genes on the X chromosome disrupt male sexual development, including reduced testosterone production	In children: learning disabilities; low testosterone during puberty leads to gynecomastia, reduced body hair, infertility. Adults: taller stature and increased risk of breast cancer/systemic lupus erythematosus (SLE).
Turner syndrome	Monosomy of **X** chromosome in females: 45 **X**	Missing copy of **X** chromosome in cells of affected females	Missing genetic material affects pre and post-natal development. Short stature homeobox ***(SHOX)*** gene loss associated with defects in bone development and growth.	Short stature. Ovarian hypofunction or premature ovarian failure. Infertility. Many do not undergo puberty at all. Webbed neck and lymphoedema in some patients. Increased incidence of heart defects
Mitochondrial disorders				
MELAS: mitochondrial encephalomyopathy, lactic acidosis, and stroke-like episodes	MT-TL1 in 80% of cases	Commonly A3243G, but various reported	*Defect in mitochondrial tRNA:* tRNA $^{Leu(UUR)}$ leading to disrupted mitochondrial energy metabolism function	In childhood: muscle weakness, recurrent headaches, vomiting, and seizures. Stroke-like episodes before 40 years of age leading to hemiparesis, altered consciousness, vision abnormalities, seizures, and migraine. Progressive reduction in motor abilities and dementia. Recurrent lactic acidosis.
Kearns-Sayre syndrome	Various mitochondrial genes	Commonly large deletion of –5000bp, leading to loss of 12 mitochondrial genes	Impaired function at every level of oxidative phosphorylation	Progressive external ophthalmoplegia, ptosis, pigmentary retinopathy. In some patients, cardiac conduction defects, ataxia, raised cerebrospinal fluid (CSF) protein.

Leber's hereditary optic neuropathy	Various mitochondrial genes	Various. Some individual with certain mutations/deletions are affected, whilst others are not. Manifests more commonly in males than females	Defects in oxidative phosphorylation pathway leads to death of optic nerve cells. The specific effect of this defect on the optic nerve remains unclear	Typical onset in adolescence or early adulthood. Progressive loss of visual acuity/colour vision in both eyes simultaneously or sequentially over a period of weeks or months. Vision loss is profound and permanent.

Diagram featuring examples of the disease located on each chromosome



BASIC IMMUNOLOGY

The immune system is fundamental to the host defense against infection and is important in protection against malignancy. Dysregulated immune responses are central to the pathophysiology of many autoimmune and inflammatory diseases.

The immune system comprises **two overlapping components**, **the innate and adaptive systems**. The innate systems.

The innate system includes physical barriers in addition to cells and soluble factors.

The adaptive system consists of an extremely broad range of **antigen-specific lymphocytes and antibodies**.

The immune cells communicate by cell-cell contact and by secretion of soluble mediators including **cytokines**.

The innate and adaptive immune systems constantly interact.

Primary lymphoid organs:

1. **Thymus:** maturation and selection of **T cells**.
2. **Bone marrow:** maturation and selection of **B cells and NK cells**, and origin of all **hematopoietic** progenitor cells.

Secondary lymphoid organs:

1. **Spleen:** processes blood-borne antigens.
2. **Lymph nodes:** processes lymph-borne antigens.
3. **Mucosal associated lymphoid tissue:** processes mucosal antigens.

INNATE IMMUNE SYSTEM CHARACTERS

1. **1st line** of defense.
2. Rapid defense, immediate onset.
3. Non-specific.
4. The same on re-exposure to **Ag.**
5. No memory cells.
6. Recognizing and react against microbes only.
7. Block entry of microbes and eliminate succeeded microbes which entered the host.
8. Lymphocyte and antibody independent.

Components

1. Barriers

Anatomical barriers:	Skin, earwax, upper airways cilia mucociliary escalator, urinary stream and bladder emptying.
Chemical and biology barriers:	- Lysozyme (Tears, GIT, saliva, breast milk, sweat. - Gastric acid (PH1). - Secretory IgA (tears, saliva, colostrum, GIT, Genitourinary tract, Prostate, Respiratory epithelium). - Normal Bacterial Flora (Skin - staphylococci, GIT- enterococci, Vagina-lactobacillus spp).

2. Innate Immune cells and soluble components

Cells	**Main function**
Granulocytes	
▪ Neutrophils	**Phagocytosis**
▪ Eosinophils	**Cytotoxicity**: extracellular pathogens
▪ Basophils	Release of inflammatory mediators
▪ Mast cells	Release of inflammatory mediators
Mononuclear phagocytes	
▪ Monocyte/macrophages	Phagocytosis (antigen presentation)
▪ Dendritic cells	Antigen presentation (Phagocytosis)
Lymphocytes	
▪ NK cells	Cytotoxicity: intracellular pathogens

Soluble	Main function
Complement pathway	Label pathogens for phagocytosis (opsonization) cytotoxicity cellular activation
Cytokines	Intercellular signaling cellular activations/suppression cytotoxicity
Chemokines	Direct cell movement cellular activation
Inflammatory mediators ▪ Prostaglandins ▪ Leukotrienes ▪ Histamine	 ▪ High vascular permeability ▪ High blood flow ▪ Cellular activation
Plasma proteins ▪ Mannose-binding lectin ▪ **C Reactive protein**	 ▪ Participate in lectin pathway of complement ▪ Coat microbes and help in phagocytosis

ADAPTIVE IMMUNE SYSTEM (ACQUIRED IMMUNE SYSTEM)

Characters:

1. **2nd line** of defense
2. Delayed as response to infection
3. Specific for microbes and Antigens (can differentiate Antigen)
4. Has memory cells which remember microbes and give strong immune response on re-exposure.
5. lymphocyte and antibody dependent
6. Allowing faster response on second encounter with antigen.

The Cellular and Soluble Components of Adaptive Immune System

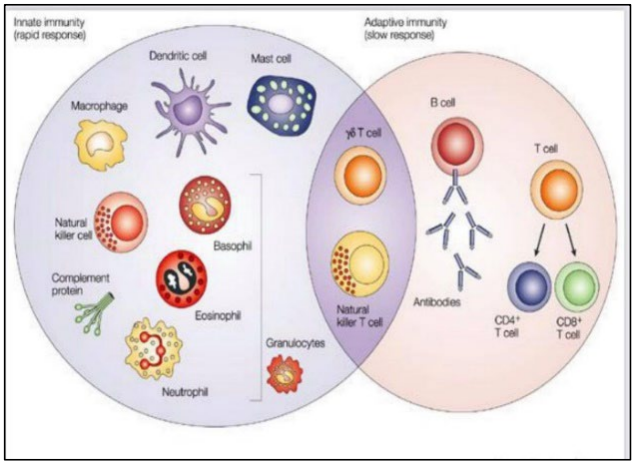
Cells	Main function
Lymphocytes ▪ **T** cells ▪ **B** cells	 Coordinate immune response Produce antibody (antigen presentation)

Soluble	Main function
Antibodies	Label pathogens for phagocytosis (opsonization) Antibody- dependent cellular cytotoxicity Activate complement cellular activation

Antigen Presenting Cells (APCs)

These include:

A : Dendritic cells
B : Macrophages
C : B lymphocytes
D : Langerhan cells



Functions

A. Capture and transport **Antigens** to the peripheral lymphoid tissues.

B. Process antigens

Present the peptides derived from these antigens to **T lymphocytes.**

Antigens

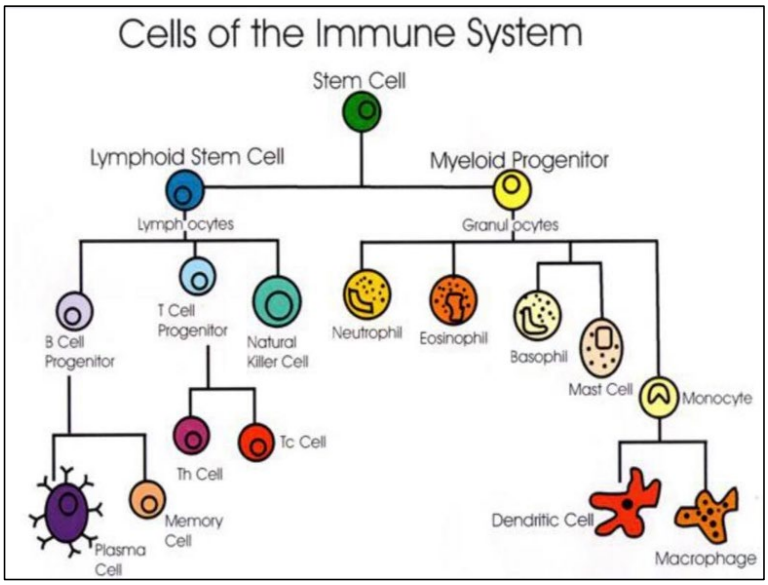
Substance reconized by immune system which may be Carbohydrate, Lipid, protein, nuclei acid, or phospholipids.

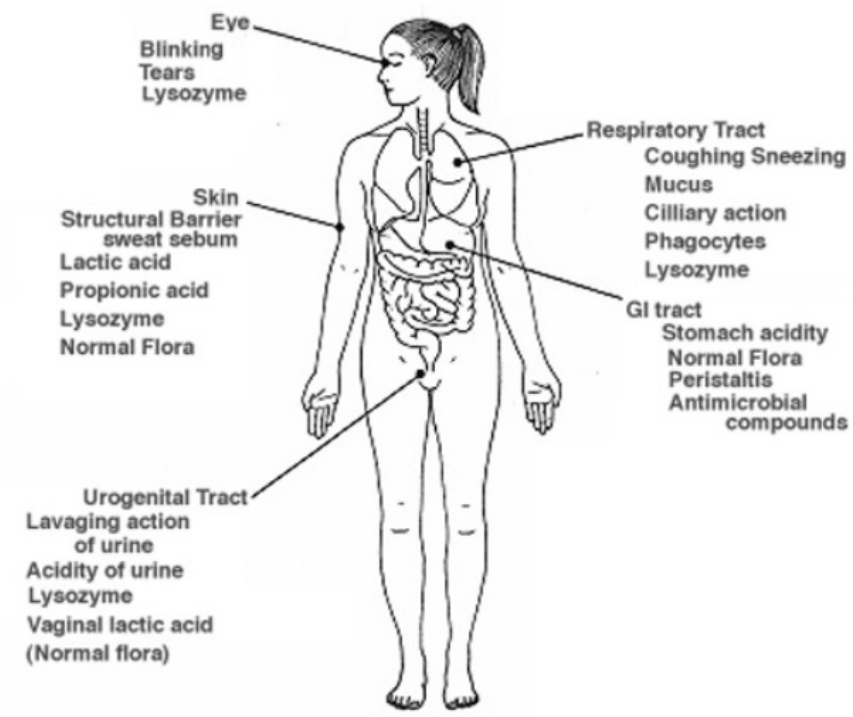
B cell recognize any biollogical Ag.

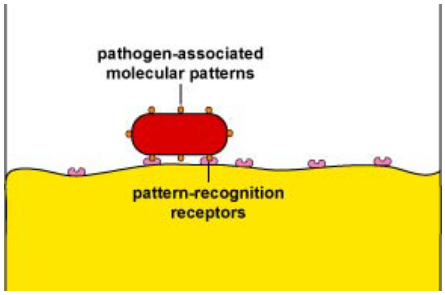
T cell recognize peptide **Ag** presented on MHC. A protein is good immunogen. Many carbohydrate, steriods, and lipids are poor immunogens.

Types of Antigens

1. **T-cell** independent antigens (**TI**): activate **B-cell** without help from **T-cell**. **E.g., pneumococcal polysaccharides.**
2. **T-cell** dependent antigens: requires **T-cell** help for B-cell activation. E.g., protein (microbial proteins & altered-self proteins).
3. **Super antigens (SAGs):** proteins produced by pathogens. Not processed by antigen presenting cells. They induce massive **T cell** activation. Large number of cytokines leading to systemic toxicity and skin syndrome diseases. **E.g., Staphylocaccal Scalded Skin Syndrome, (SSSS).**



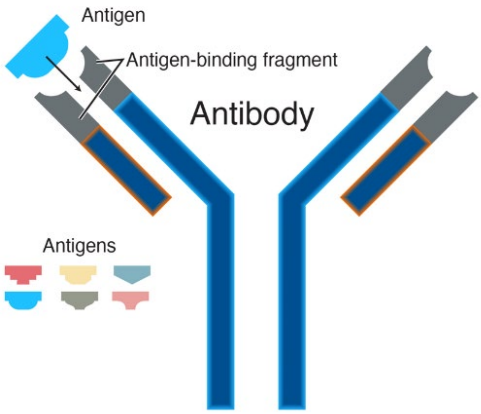




Antibody

An antibody, also known as an immunoglobulin, is a large **Y shaped** protein used by the immune system to identify foreign objects such as pathogenic bacteria and viruses. The antibody recognizes a unique molecule of the pathogen, called an antigen.

- Secreted by plasma cells and B lymphocytes
- Bind to specific Ag
- Neutralize
- Block attachment
- Label
- Activate complement
- Trigger cytokine release
- Present **Ag to T cell**

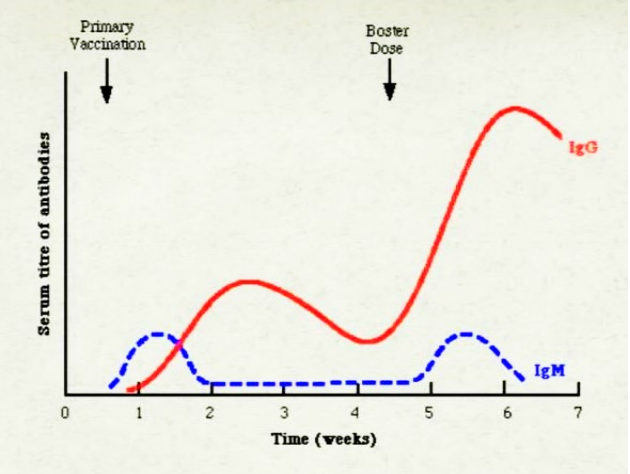


Key classes of Ab

- **IgM**-low affinity in primary immune responses, complement activation, largest Ab, does not cross placenta.
- **IgG**-high affinity, most important class of **Ab** in secondary immune responses, crosses placenta.
- **IgA**- found in primarily in secretions such as Breast milk, tears, saliva and mucosal membranes.
- **IgE**- evolved to provide protection for parasitic infections, associated with allergic diseases e.g., asthma, hay fever.
- **Ig D**- Ig D is primarily found on the surface of B lymphocytes. The function is to signal the B cells to be activated.

Primary Immune Response

When we are exposed to an antigen for the first time, there is a lag of several days (10 days) before specific antibody becomes detectable. This antibody is **IgM**. After a short time, the antibody level declines.



Secondary Immunes Response

If at a later date we are re-exposed to the same antgen, there is more rapid appearance of antibody, and in greater amount. It is of **IgG** class and remains detetable for months or years.

CYTOKINES

Cytokines are small proteins and made by many cell population, but the predminant producers are helper **T cells (Th)** and macrophages. When released, they signal the immune system to do its job. Chemokines are small cytokines. Its function is to recruit or guide the cell of the immune system to a site of infection. **Chemokines** are released by infected cells or damaged cells. The attracted cells move through the gradient towords the higher concentration of chemokines.

Interleukins are a group of cytokines that play crucial role in proliferation, activation, maturation, and differentiation of immune cells. The majority of interleukins are synthesized by helper **CD4** lymphocytes as well as through monocytes, macrophages, and endothelial cells.

Interferon gamma is an important **cytokine** produced primarily by **Th1 cells**, also by **Tc** and **NK** cells. There are three types of interferons **IFN alpha**, beta and gamma. **IFN**-alpha is produced in the leukocytes infected with virus, while **IFN-beta** is from fibroblast infected with virus. **IFN-gamma** is induced by the stimulation of sensitized lymphocytes with antigen or non-sensitized lymphocytes with mitogens (inducer of mitosis).

The major acute innate cytokines, IL-1, TNF-alpha, IL-6, IL-12,CXCL8 (IL-18), G-CSF (granulocyte colony-stimulating factor), and GM-CSF (granulocyte macrophage colony stimulating factor) are used locally to activate endothelial cells and local tissue leucocytes (mast cells, dendritic cells ,rd T cells).

Cytokine Storms

Example

The novel coronavirus gains entry into humans by targeting the **ACE2 receptor** that found on lung cells, which destroy human lungs through **cytokine storms**, and this leads to **hyperinflammation**, forcing the immune cells to destroy healthy cells. This is why some **covid-19 patients** need intensive care.

The **covid-19** patient with cytokine storm had higher levels of **CXCL 10,IL-6, CCL2, and TNF-alpha**.

Leukotrienes

Inflammatory molecules called leukotrienes are one of several substances which are released by mast cells during an asthma attack. Leukotrienes are primarily responsible for the bronchoconstriction. Leukotrienes cause tightening of airway muscles and the production of excess mucus and fluid. These chemicals play a key role in allergies, allergic rhinitis and asthama, also causing a tightening of your airways, making it difficult to breathe. Leukotrienes have become identified as villains of the immune system.

Prostaglandin

In higher concetrations, prostaglandin may trigger release of histamine from mast cells or basophil leucocytes. Histamine is stored in intracellular granules of basophil and is released following cell stimulation.

Histamine

Once released from its granules, histamine produces many varied effects within the body, including the contraction of the smooth muscle tissue of the lungs, uterus, and stomach, the dilation of blood vessels which increases permeability and lowers blood pressure, the stimulation of gastric acid secretion in the stomach. This inflammation acts like a lighthouse for the immune system so your body can go to the source and treat it. When we take antihistamines, we turn down this inflammation.

MAJOR HISTOCOMPATIBILITY COMPLEX (MHC)

Group of genes on short arm of chromosome 6 which produce MHC molecules present on cell surfaces and responsible for display of protein Ag to T cells. Also called **human leucocyte Ag (HLA).**

Classification of genes

Class I MHC genes	:	HLA-A, HLA-B, HLA-C; role in Ag presentation to Tc
Class II MHC genes	:	HLA-D, HLA-DR, HLA-DP, HLA-DQ; role in Ag presentation to Th.
Class III MHC genes	:	lies between class I & II & not produce MHC but produce some complements components and TNF-alpha.

Certain HLA are associate with autoimmune disease:

- HLA B-27 : seronegative arthritis
- HLA DR3: Sjogren's, Syndrome, autoimmune hepatitis, type I DM.
- HLA DR-4: Rheumatoid arthritis, T1DM

COMPLEMENT SYSTEM

A system of circulating and membrane associated proteins that function in both the innate and adaptive branches of the immune system.

Lymphocytes

- Lymphocytes are the only cells with specific receptors for antigens and are the key mediators of adaptive immunity.
- They can be distinguished by surface proteins identified by monoclonal antibodies the standard nomenclture fot these proteins is the "CD" (cluster of differentiation) and a number; for example CD1, CD2, CD3, etc..

Lymphocytes include

- **B lymphocytes: mediators of humoral immunity**
- **T lymphocytes:** mediators of cell-mediated immunity.
- **Natural killer cells:** cells of innate immunity.

	B lymphocyte	T lymphocyte
Arise from	Bone marrow	
Mature in	Bone marrow	Thymus
Name	Bone marrow lymphocytes	Thymus derived lymphocytes
% of total blood lymphocyte	10-15%	Majority
Steps in maturation	Stem cell→lymphoid progenitor→pre B cell→ immature B cell→mature/naïve B cell→leave bone marrow to meet antigen in the 2nd lymphoid organs	Stem cell→lymphoid progenitor→immature T cell→leave bone marrow to thymus gland→maturation & selection→mature/naïve T cells T helper (CD4) T cytotoxic (CD8) →leave thymus to meet antigen in the 2nd lymphoid organs
Phenotypic markers	1. CD 19 & CD 21 2. Fc receptor 3. Class II MHC molecule	1. CD3 2. CD4 or CD8 3. T cell receptor (TCR)
Function	Antibody production (humoral immunity)	Cell mediated immunity
Antigen recognized	Protein, polysaccharide, lipid, nucleic acid and small chemicals (free & soluble)	Protein only - CD4 cell recognize→peptide + MHC II molecule - CD8 cell reconize→peptide + MHC I molecule
Antigen recognition receptor	**B cell receptor (BCR):** membrane Immunoglobulin (IgM & IgD)	**TCR: 2 types α/β TCR & γ/δ TCR** **α/β TCR:** common type→2 poly peptide chain **α & β**
Stimulation by Ag	B cell proliferation→differentiation into→memory cell & plasma cell which produce antibodies to eliminate Ag	**TCR complex:** - Ag presented on MHC, bind with variable domain of **α & β** of **TCR** - CD3 & zeta protein (signal transduction) →activate T cell
Signaling molecules	2 polypeptide chains→ Ig **α & β** transmit signal inside B cell → B cell proliferation & differentiation into plasma cell	TCR & CD3 & zeta protein
Types	1. Naïve B cell 2. Plasma cell 3. Memory cell	1. **T helper (CD4)** → produce cytokines which help other cells eg 2. **Th2** help B cell to produce antibodies 3. **Th1** help macrophage to destroy ingested microbes 4. **T cytotoxic (CD8)** Also called cytolytic as lyse virus infected cell & kill tumor cell & graft rejection

Type	Alternative names	Antibodies or Cell Mediators	Immunologic Reaction	Examples
I	▪ Allergy ▪ Immediate Anaphylatic	Antibody IgE	Fast response which occurs in minutes, rather than multiple hours or days. Free antigens cross link the **IgE** on mast cells and basophils which causes a release of vasoactive biomolecules. Testing can be done via skin test for specific IgE.	▪ Atopy ▪ Anaphylaxis ▪ Asthma Churg-Strauss Syndrome
II	▪Cytotoxic, Antibody-dependent	▪ Antibody IgM ▪ Antibody IgG ▪ Complement MAC	Antibody (**IgM or IgG**) binds to antigen on a target cell, which is a actually a host cell that is perceived by the immune system as foreign, leading to cellular destruction via the MAC. Testing includes both the direct and indirect Coombs test.	▪ Autoimmune hemolytic anaemia ▪ Rheumatic heart disease ▪ Thrombocytopenia ▪ Erythroblastosis fetalis ▪ Goodpasture's syndrome ▪ Graves' disease ▪ Myasthenia gravis
III	Immune complex	▪ Antibody IgG ▪ Complement Neutrophils	Antibody (IgG) binds to soluble antigen, forming a circulating immune complex. This is often deposited in the vessel walls of the joints and kidney, initiating a local inflammatory reaction.	▪ Serum sickness ▪ Rheumatoid arthritis ▪ Arthus reaction ▪ Post streptococcal glomerulonephritis ▪ Membranous nephropathy ▪ Reactive arthritis ▪ Lupus nephritis ▪ Systemic lupus erythematosus Extrinsic allergic alveolitis (hypersensitivity pneumonitis)
IV	▪ Delayed ▪ Cell-mediated immune memory response, ▪ Antibody-independent	Cells T-cells	T helper cells (specifically T_h 1 cells) are activated by an antigen presenting cell. When the antigen is presented again in the future, the memory Th1 cells will activate macrophages and cause an inflammatory response. This ultimately can lead to tissue damage.	▪ Contact dermatitis. Including Urushiol-induced Contact dermatitis (poison ivy rash) ▪ Mantoux test. ▪ Chronic transplant rejection. ▪ Multiple sclerosis ▪ Coeliac disease ▪ Hashimoto's thyroiditis Granuloma annulare

1. Primary (inherited)
2. Secondary (Acquired)

Primary Immunodeficiency

Deficiency of any component of the innate or adaptive immune system may produce clinical consequences. E.g.,

(a) Hereditary ataxia telengiectasis

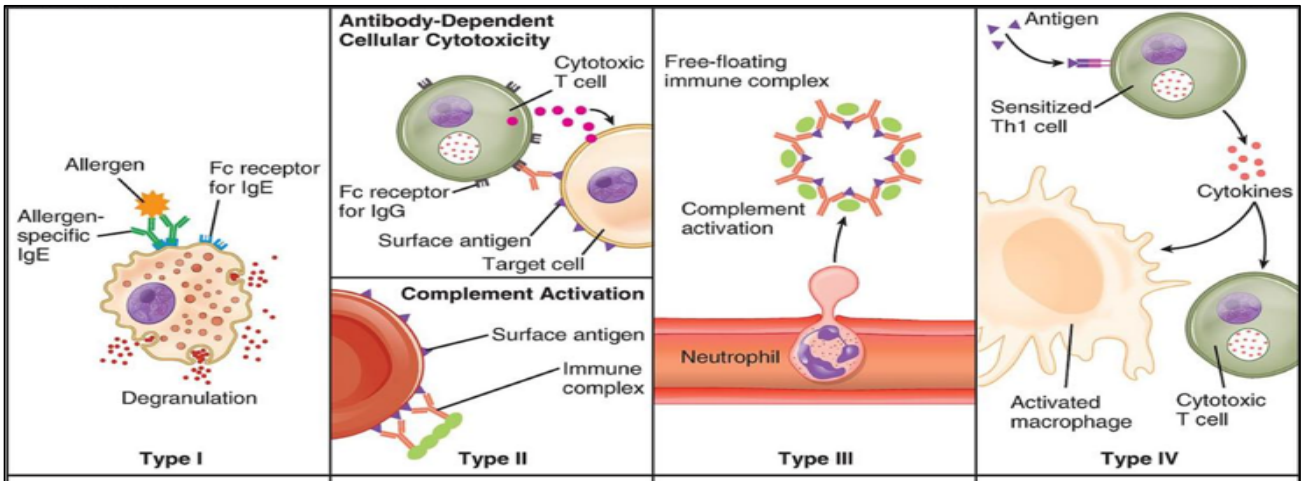
Cause: chromosomal detects on 7 and 14.
Deficiency: T cell number and function reduced.

(b) Di George Syndrome

Cause: Deletion of chromosome 22 q 11.2
Deficiency: Reduction in **T cell** numbers

Secondary (Acquired) Immunodeficiency

(a) HIV infection
(b) Immunosupress drugs
(c) Metabolic disease (diabetes)
(d) Autoimmune disease (Rheumatoid arthritis, SLE)
(e) Drugs (Phenytoin, Colchicine)
(f) Malnutrition



IgE-Mediated Hypersensitivity	IgG-Mediated Cytotoxic Hypersensitivity	Immune Complex-Mediated Hypersensitivity	Cell-Mediated Hypersensitivity
IgE is bound to mast cells via its Fc portion. When an allergen binds to these antibodies, crosslinking of IgE induces degranulation.	Cells are destroyed by bound antibody, either by activation of complement or by a cytotoxic T cell with an Fc receptor for the antibody (ADCC)	Antigen–antibody complexes are deposited in tissues, causing activation of complement, which attracts neutrophils to the site	Th1 cells secrete cytokines, which activate macrophages and cytotoxic T cells and can cause macrophage accumulation at the site
Causes localized and systemic anaphylaxis, seasonal allergies including hay fever, food allergies such as those to shellfish and peanuts, hives, and eczema	Red blood cells destroyed by complement and antibody during a transfusion of mismatched blood type or during erythroblastosis fetalis	Most common forms of immune complex disease are seen in glomerulonephritis, rheumatoid arthritis, and systemic lupus erythematosus	Most common forms are contact dermatitis, tuberculin reaction, autoimmune diseases such as diabetes mellitus type I, multiple sclerosis, and rheumatoid arthritis

COMMON MEDICAL CONVERSIONS

Liquids	15	dp	1	ml
	1	oz	30	ml
	1	ml	1	cc
	1	tsp	5	ml
	1	tbs	15	ml
	8	oz	240	ml
	1	quart	2	pints
	1	L	1000	ml
Temperature	0	°F	-17.8	°C
	98.6	°F	37	°C
	212	°F	100	°C
Weight	1	oz	28.349	gm
	1	mg	1000	mcg
	1	g	1000	mg
	1	lb	16	oz
	1	kg	2.2	lbs
Length	1	in	2.54	cm
	1	yard	3	ft

Abbreviations

dp = drop
oz = ounce
ml = milli-liter
tsp = teaspoon
tbs = tablespoon
L = liter
cc = cubic centimeter
°F = degree Fahrenheit
°C = degree Celsius

gm = gram
mcg = microgram
g = gram
kg = kilogram
lb = pound
in = inch
ft = foot/feet

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